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THE TESTING OF CAST IRON.*

By DR. RICHARD MOLDENKE, Secretary to the American Foundrymen's Association.

BUT few of the materials of construction have received as much attention in recent years as cast iron; and, indeed, it was high time that this study was taken up, for in no one branch of the great iron industry was there so much need of light.

We are to-day gradually working toward uniform methods for the production of the highest grades of material for all classes of castings.

The best results were, of course, obtained with the specialities, for here an individual investigator had at his command a wide range of experience in one particular line and with his special materials. Chilled rolls, the malleable casting, ingot moulds, stoves, pipe, gun iron, and specification castings for Government and other work; all these special lines at the present time exhibit a perfection in the state of the art considered impossible not so long ago.

The natural result of all this effort is that the consumer learns with the producer, a little slower perhaps, but nevertheless sufficiently to enable him to discriminate between the methods and results of the progressive founder, and the man who does not care, or is content to do things as his forefathers did. Hence, specifications are the order of the day. In the case of cast iron, the movement for standard specifications for the products of the industry emanated from the foundrymen, and not the buyers. This was because foundry owners were quick to note that giving a good grade of material voluntarily meant the staving off of unreasonable demands otherwise made by purchasers not fully up to date in foundry practice.

It was not long after the nature of cast iron was better understood that the

* Paper read before the Franklin Institute.

American Foundrymen's Association, which freely encouraged all these investigations, requested the American Society for Testing Materials, the clearing house of the nation's industrial life, to promulgate standard specifications for testing cast iron and finished castings. Foundrymen, metallurgists, and representative buyers alike worked on this problem, with the result that to-day there have been adopted standards for the purchase and sale of foundry pig-iron, cast iron pipe, locomotive cylinders, malleable castings; and there are pending specifications for the testing of cast iron in general, and cast iron car wheels.

As a side line in the testing of cast iron, the materials used in its production are also coming in for their share of attention. Thus we have just in process of organisation an important committee on preparing standard specifications for the purchase and sale of foundry coke. The adoption of such a standard, which shall at the same time be fair to the coke-maker. and the foundryman, will mean a great stride forward, and one more source of constant annoyance will have been mitigated, if not altogether removed. Those who are not right in touch with actual conditions cannot realise the damage caused by high sulphur coke just when castings of special strength or softness are wanted.

Eventually we may see moulding sands and facings the subject of standardisation. Indeed, for those who have given these minor and yet important matters close study, the day that intelligent and effective specifications are devised to take care of them will be a happy one.

With these general remarks we can now take up in more detail the characteristics of cast iron upon which an intelligent and correct system of testing it can be based.

The strength, appearance of the fracture, resistance to cutting tools, density, melting point, etc., of a cast iron depends upon the relative proportion of graphitic and combined carbon present, both together making up the total carbon. That is, if the total carbon is nearly all present in the graphitic or uncombined state, the iron will be soft, in fact, a mild steel with the interstices between the crystals filled with graphite. The fracture will also be gray or almost black. If, on the other hand, the carbon present is all or nearly all combined, the iron will be white or mottled, hard, so that tools cannot touch it, and not good for the ordinary purposes cast iron is supposed to be used for. Everything else being normal, carbon in cast iron is at the same time its most important and yet its most easily influenced ingredient.

We have only to run up the silicon content of a cast iron to change an otherwise white iron to a grey one; or leaving the silicon low, to cool the metal from the liquid state very slowly, to produce the same result. Then, again, if we take a high silicon iron and cast it against an iron chill plate, we prevent the separation out of the graphite, by not giving it time to do so before the metal is solid, and the result is an iron which is at least very closely grained and light grey, if not actually white at the point of contact with the chill. The same condition of things, though in a very much smaller measure, is observed by pouring an iron exceedingly hot.

The other elements present in cast iron naturally have their effect also, and attention is called to this fact only in so far as it will explain the reason why these elements, together with the carbon, and also the relative proportion of pig-iron and scrap, the method of melting, and the subsequent manipulation in the foundry; all together have given us at least twelve distinct classes of iron castings, based on the characteristics of the metal only, and some forty-three general classes of castings, the iron in each of which is a little different from that in the others.

Without going further into this, it will suffice to say that unless due regard is given the composition and the peculiarities of heat treatment as outlined above, in any system for testing cast iron, it will not be worthy of our confidence.

It will, of course, be understood that when dealing with extremes in composition of a cast iron, in the rapidity or slowness of the cooling, and the temperature of the pour, or in the combination of two or more of these points, that the phenomena observed as to strength, appearance, and general character of the resulting castings, are very strongly apparent. Where, however, the composition of the iron is normal, that of a grey one, where it is cast neither too hot nor too cold, and is let to cool down under ordinary foundry conditions, one does not notice half a dozen different varieties of iron in the same casting.

To illustrate this point by an example directly from the foundry testing room. A test bar one-half inch square and broken transversely on supports 12 in. apart, is much used by the stove trade, to get the strength and contraction measurements. This bar is claimed by

its friends to be infallible for all uses except perfectly white iron. Yet it so happens that no bar is so easily affected in its arrangement of the carbon content as this one, by the greater or less dampness of the moulding sand, the temperature at which the iron is poured, not to speak of the composition of the iron itself, which makes a small bar very sensitive. A ladle full of hot iron from which a mould is poured, is then let stand for a while until pretty dull; then another mould poured for the same sized bar will give two tests of different strengths and different contraction measures. The stove founder had better make his tests on bars which are larger in section and hence not so influenced by inequalities in foundry practice.

If test bars were made round instead of square, one very evil effect would be obviated. The chilling of the edges by quick cooling always produces in them proportionally more combined carbon than would be the case in a round section. The chilled edges are therefore harder, and at least artificial as regards the legitimate nature of the iron. In some specifications a broken square bar is turned up round for further tests. This, it will readily be seen, leaves the resulting round bar with four hard and four soft places in the surface of the cylinder. Just how a bar of this kind can truly represent the iron in the castings it would stand for is an open question.

Suppose, then, we make a test bar round instead of square, and quite large in section—let us say over one inch in diameter. The metal in the mould will then have time to cool normally, the dampness of the sand will not affect it so much in the first place, and if the metal has been cast unduly hot, it has a chance to lose its excessive heat before much of it has set against the surface of the mould. Chemically speaking, the silicon in the iron has a chance to get in its work, throwing out the proper amount of graphite at the moment of set, and while the skin of the casting will be finely grained, and the interior coarsely so, the structure changes uniformly from the surface inward, without the extra complication of chilled corners thrown in. The general trustworthiness of such a round large bar is certainly much greater than a little square one, which may be made to show anything you like by suitable manipulation.

Now to go one step further. If a test bar or any flat casting is moulded up horizontally and cast in that position, the metal flowing into the mould through the comparatively narrow gate, will first roll along the bottom of the mould, heating up the sand there, but cooling the iron. Now, as more iron is forced in, the cold iron is pushed upward by it, eventually touching the cold sand in the top of the mould, while the last hot metal sets on the hot sand of the bottom. The result is a considerable difference of conditions in top and bottom of the casting, and this is quickly noticed if the material is tested cope side up, or cope side down.

To avoid this trouble, the only rational method of moulding would be to get the test bars standing upright, and to flow the iron in either from the top, or to let it run upward from the bottom. This latter method gives the best results, but is too expensive for ordinary foundry use. If carefully poured from the top, especially if the bottom of the mould is rounded up, so that the stream of iron falling in does not shot itself, the bars made leave nothing to be desired. We now have round bars of large diameter cast vertically, as more reliable when compared with smaller square ones cast flat.

The next step to be considered is whether the mould cannot be made so that its nature does not artificially strengthen or weaken the test bars. This is done by subjecting the ordinary green-sand article to a drying process. As all of our foundries are equipped with drying facilities for their core work, this provision for the greater accuracy of a test bar in representing the metal it is cast for can be easily carried out. A flask for test bar purposes should therefore be made of iron, so that the mould can be dried in a core oven and cooled before casting.

Perhaps we should before going further discuss the very idea of testing cast iron as it is carried out to-day, so that the reasoning therefore may be understood. The only way to know whether a casting will stand up under the service strain it is supposed to undergo, is to put it under such conditions, and see if it will pass muster. For safety, we always put it under a test at least 25 per cent. to 50 per cent. more severe. Now we cannot test the thousands of castings that are made daily, nor are many of the castings made in such a shape that we can apply any tests which will give us the desired information. Some, however, are, such as the car wheel, and here three are taken from a given lot of 103, and broken under what comes as near to service conditions as can be made possible, short of actually putting them in a train and wrecking this by excessive severity.

Again, pipe may be put under bursting pressure, car couplers may be pounded by

drop weights, etc., but for the great majority of castings no way can be devised to give us an inkling of what they will actually stand by a direct test.

For this reason it has come to be conventional to take bars of cast iron, of the same ladle as the castings, or at least from the same heat, at regular intervals. These bars of iron are broken either transversely, or under tensile strain, or both, and from them we learn what was the quality of the iron which went into the castings. It stands to reason that when we are put to it to judge our castings by another casting, different in shape, and tested under conditions different from what will be the case with the original work, we certainly do not want to deceive ourselves in any particular about what we are doing. The key-note of American testing practice, so far as cast iron is concerned, is, therefore, to give the iron put into the test bars the very best chance possible to exhibit its properties just as they are, neither artificially strengthened, nor weakened, by irregular foundry manipulation. If the iron thus cast shows up to be of first-class quality, the castings the tests are to stand for will also be of good iron, and it should, in fact must be, left to the knowledge of the founder of his business to see that the moulding and pouring conditions for the castings are such that the best possible results are obtained.

The wise founder, therefore, will always open his laboratory fully to the inspector of the purchaser, it being his safest guarantee that the greatest possible care is taken to have none but the best material to start with, and none but the best practice to use it.

Some further items on the test bar question must not be forgotten. In the first place, it is important that the bars be not rumbled, or treated otherwise than simply brushing the sand off. Mr. Outerbridge was the discoverer of the remarkable strengthening effect of the rolling barrel on castings, the molecules of which are brought to their normal positions by this rattling process.

The speed of testing is also important, for a bar broken unduly quick is apt to show higher figures than one tested unduly slow.

Now, as to the pressure put on the test bars in breaking them. The transverse test is always preferred by those who are familiar with the characteristics of cast iron, not because the tensile test is not better, but because the difficulties in getting a fair tensile test on cast iron are so great that the slightest imperfection in the machine grips, or the skin of the bar, etc., will give a side pull, which reduces the record so abnormally that an otherwise good iron will be condemned. The transverse test also dealing with figures about one-tenth as large as the tensile requirements, allows every foundryman to have his own small machine. He can, therefore, make daily tests for the purpose of checking his work, and can thus, if he wishes it, steadily improve his output in quality.

Another point that must be considered in the preparation of the test bar which is to be used under the tensile test, is the necessity of removing the skin. Every casting has the surface covered with very fine hair cracks to a greater or less extent, accordingly as the metal is hard or soft. Now in pulling apart such a bar, rupture will take place much sooner at one of these cracks than at any sound place. As these cracks are never deep, but in the skin only, cutting off enough metal to get below will remove this danger. For this reason the broken parts of a transverse bar after the test can be turned up to remove the skin and then pulled under tensile strain.

We have now gradually developed the ideal conditions under which any system for testing cast iron, and the preparation of test bars, should be undertaken. Perhaps we may have omitted some details inadventently, but it is hoped not. We must now take into account certain commercial limitations, which cannot be avoided, otherwise even the best system will not be used. First of all, any system for testing cast iron which is to be the basis of specifications must not be burdensome to the founder, while amply protective for the buyer. That would mean that the necessary moulding, pouring, and finishing should be done without interfering with the making of the actual castings. The number of test bars must not be too great, and they should be cast from the first and the last of the heat, and enough between to make a given number of tons of castings represented by sufficient bars to prove them up. All these bars should be tested, and if only one bar of the two or more made in each mould passes, this should be sufficient. However, one must pass out of every mould poured, otherwise the iron would be open to suspicion. As the ordinary limit of the commercial transverse testing machines in the foundry is about 5,000 lbs. this figure should not be exceeded in designing the bar. For tensile tests this is a different matter, as the bars in any case would have to go to the very best testing

laboratories available. In fact, where a tensile test is demanded, the work entailed is so onerous and expensive that no founder should be expected to stand it, and hence it should be charged to the buyer. The same can be said in cases of dispute, where both buyer and seller claim to be right. On calling in an outside expert, satisfactory to both parties, the loser should always pay the bill. This is mentioned merely by the way, as it forms the substance of one clause in the pig-iron specifications recently adopted.

A further commercial limitation is the speed of testing. This should be as high as it can, consistent with correct results. Elaborate experiments have been made along these lines, and the conclusion arrived at is that a rate of application of the load for 30 seconds to give a deflection of 1-10 in. is about right for cast iron. As already stated further above, when tensile tests are demanded, the test pieces should be turned up from the ends of the bars broken in transverse test. This saves the casting of extra bars. Of course, it is understood that the founder can cast as many extra bars as he likes for his own information, as it is at his own expense, but once he knows his own record from daily observation, he will not need to do this, except perhaps for Government work, where usually the price received allows of all kinds of precautions.

While considerable stress has been laid on the total carbon in its two divisions, one other element should come in for some notice also, as it has a far-reaching effect on the strength and hardness of a casting. This is the sulphur. When this element is present in excess, we have all kinds of trouble in service. It is therefore necessary to limit the quantity allowable in castings, and this limit depends upon the thickness of the work. A heavy casting can carry more sulphur than a small one, for in the latter the hardening effect is more perceptible. While sulphur, therefore, must be made an item in all cast iron specifications, the other elements, carbon included, need not be, as the combination of iron with silicon, carbon, manganese, phosphorus, and sulphur, as found in the varieties of cast iron, gives evidence of the amounts present by the strength of the bars under test. A specification which has the physical requirements prescribed, and also takes into account all the chemical ones, would be burdensome. On the other hand, if only chemical specifications were given, and the physical requirements left out, no account would have been taken of irregular or incorrect heat treatment in the foundry.

Another matter in which commercial considerations had to be reckoned with more than was desired from the standpoint of scientific testing, was the selection of a standard test bar. The correct diameter of a test bar for a given class of iron can be readily learnt by casting a series of round bars in dry sand ranging from half an inch upwards to about four inches in diameter. On breaking them transversely, the fracture should be noted. The small bars will be very closely grained and dense; in the case of low silicon irons they will even be white. As the diameters grow larger the grain opens, and soon a point is reached when open spots appear in the structure. The metal at a point just before this happens will be in its best and proper condition. For instance, take chilled roll iron. The small bars are all white. As they increase in size the metal becomes mottled, then grey, though finely grained. Not until a diameter of three inches is passed will the metal begin to show very slight signs of irregularity in the density. Hence a bar for test purposes should be at least three inches in diameter. But where will a testing machine be found in common use to break such bars transversely with supports 12 in. apart? Good metal of this kind will run near or over 100,000 lbs. for this test. Again, with ordinary castings the critical diameter is about 1½ in. Yet here also the transverse strength exceeds 5,000 lbs., or the limit of the ordinary testing machine. Hence in the so-called "Arbitration Bar," adopted by the Committee which has studied this question, a bar 1¼ in. in diameter and 15 in. long has been selected, to be tested transversely on supports 12 in. apart.

In selecting this distance for the knife edges, we differ radically from German practice. In Germany they are inclined to adhere to the old method of taking very long bars and bending them slowly. We used to do this here ourselves, and the day is not so long past when a 5-ft. bar, 1 in. square was treated to a 500 lbs. weight suspended at the centre. If it stood up, the castings it represented passed, if not, they were rejected. One can readily imagine how slowly and carefully the foundryman lowered the weight from the crane upon the bar, and how carefully the chain was examined so that no unexpected kinks might open up at a critical time, making a weak bar snap untimely where it would

otherwise stand up all right with proper nursing.

My own investigations on bars of various lengths and of the same cross-section have shown me very conclusively that the longer the bar, the less sensitive it is to bending and shock. As cast iron, unfortunately, is the very worst material that can be used under shock, and as no castings in ordinary service are not subject to it, a test should take this into account. With the bars very short, say, on 12-in. supports, ample opportunity is given to see how the metal stands the fairly quickly applied load. If, however, the load is put on slow and the bars are very long, time is given for the molecules to adjust themselves to the changing conditions, and the result is an artificially good value.

In concluding, it might be well to run over the salient points of the standard specifications for cast iron, proposed in America. They will show how well the arguments advanced in this discourse have been considered by the Committee above referred to.

Cupola metal is supposed always to be used unless furnace iron is specified.

Castings are divided into three classes, those below ½-in. in thickness being called light; those between ½-in. and 2 in. being medium, and those above, thick. The sulphur content in these classes shall not run over .08, .10, .12, for the light, medium, and thick castings. Similarly the transverse breaking strength of the arbitration bar shall be up to 2,500, 2,900, and 3,200 lbs. for these classes, while the tensile strength, if demanded, is to be up to 18,000, 21,000, 24,000 lbs. per square inch. In the case of the transverse test, the deflection shall in no case be under 1-10 in. before the bar breaks.

The sulphur determinations are to be made from these broken pieces.

The castings must be true to pattern, free from cracks, flaws, and excessive shrinkage, but otherwise in finish as specially agreed upon, for it may often happen that an extra fine finish is not wanted, and the price is made accordingly.

The inspector is to be given all possible but reasonable facilities for assuring himself that everything is all right.

Now, as to the "Arbitration Bar." Two sets of two bars shall be cast from each heat, one from the first and one from the last of the iron going into the castings made under specification. Then, if the heat exceeds 20 tons, another set of two bars are to be cast for each 20 tons or fraction over, in addition to the two sets above mentioned. If the mixture changes during the heat, another set of bars for each change. All of these bars are to be broken transversely, and one bar from each set cast must fulfil the conditions. Tensile tests, though not recommended, may be made from the broken pieces of the arbitration bars, but the cost of turning these test pieces down to 0.798 in. diameter, together with the screw ends for the machine, must be borne by the purchaser.

The mould, which may consist of a piece of 10-in. pipe, properly bored for venting, has another piece of pipe for a cope, which holds the pouring basin and funnel gates. The two patterns of the bar are moulded in a vertical position, drawn out, and the mould closed. Then it is dried, and cooled before filling with the metal in question. The patterns are so made that the bottom is rounded, and a taper of 1-16 in. downward provided, so as to make up for the strain of pouring. Even the facing is provided for, being sand with bituminous facing 12 to 1, all moulding sand being put through a No. 8 sieve before using.

The speed of testing is given at a deflection of 0.10 in. in thirty seconds.

Finally, it may be added that as we learn more of the characteristics of cast iron, we may be able to improve the methods of testing it, but it is pretty safe to say that in America, at least, the producer of the castings will be the one who, by his ceaseless struggle for advancement in product, attains this desired end.

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Mr. J. Ford, of the Jubilee Nut Works, Farnworth, has just established the Park Lane Foundry, Tipton, Staffs.

In reference to the many rumours circulated concerning the well-known firm of Graham, Morton & Company, of Leeds, it may interest our readers to learn that, although owing to circumstances beyond their control, including a law suit, which the firm won, both on the claim and counter-claim, involving over £75,000, the company deemed it advisable to seek voluntary winding-up powers, it has now been reconstructed on a perfectly satisfactory basis. Mr. Maurice Graham remains at the head of affairs, and Mr. Morton is, as before, associated with him. Graham, Morton, Limited, has been registered with a capital of £125,000 in £1 shares (85,000 7 per cent. cumulative preference), to acquire the business of Graham, Morton & Company, Limited.

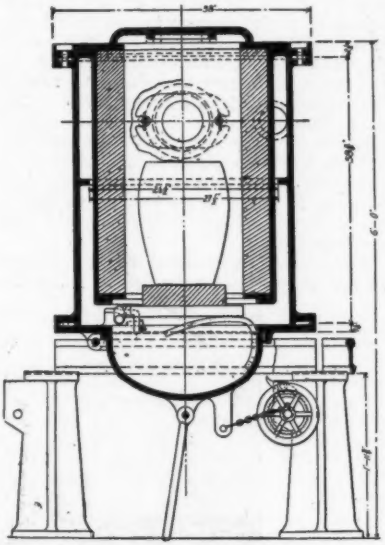
A DESIGN FOR BRASS FURNACES.

THE accompanying illustrations show in detail a brass furnace, designed by Mr. George F. Wilson, superintendent of motive power of the Chicago, Rock Island and Pacific Railway. The furnaces have been so designed that any number of crucibles may be added to or taken from the battery without materially disturbing the existing plant.

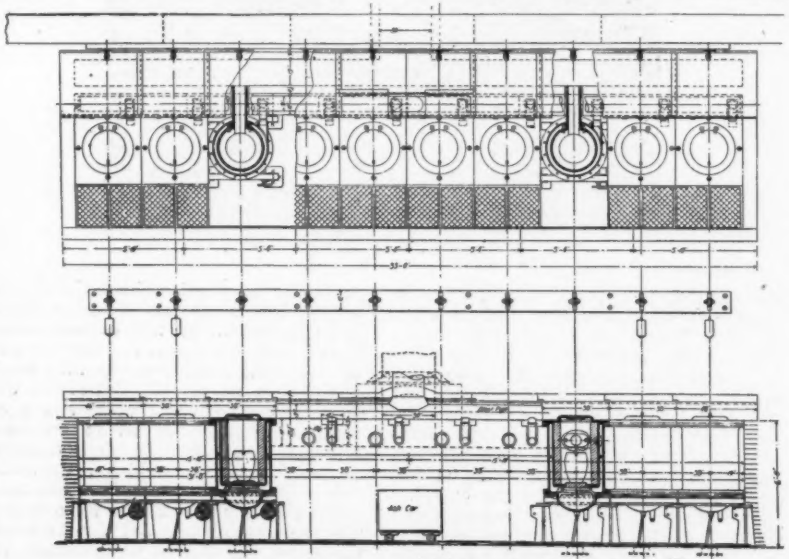
The illustrations show a plan of the furnace, a side elevation, and one of the retorts in detail. The furnaces have been arranged so as to be easily accessible for repairs, and provision is made for ready cleaning, and for the proper disposition of the ashes.

The furnaces occupy a pit 6 ft. deep and 6 ft. 3 in. wide. The length, of course, is governed by the number of retorts; in this case it is 31 ft. 8 in. inside. The retorts are placed side by side and are supported by two cast-iron I-beams, which lie parallel lengthwise of the pit and rest on cast-iron columns 24 in. high. The columns are spaced midway between the retorts the entire length of the pit. These occupy one side of the pit; the other side is taken up by a track for the cinder car, which runs parallel to the furnaces

The retorts are formed by an outer cylinder of cast iron, in which an inner cylinder is placed. Their relative diameters are such that an air chamber 2 in. wide is formed between the two cylinders. The inside of the inner cylinder is bricked



SECTIONAL VIEW OF BRASS FURNACE RETORT.



PLAN AND SECTIONAL ELEVATION OF BRASS FURNACE.

with fire-brick, and is provided with a drop-grate, which is hinged at one side and held in place by means of the ash receiver, as plainly shown in the detail cut. The No. 80 crucibles rest on the grate, the whole being covered by the door at the top, which for convenience of raising has balance weight attachments. The curved piece secured to the inner side of the ash receiver serves to automatically lift the grate to place as the receiver is raised by means of the hand wheels. The receiver is made large enough to hold a charge of molten metal should the crucible burst.

The blower pipes for these furnaces are laid in the conduit provided as a flue for the escaping gases, and as a result the temperature of the forced draught when reaching the retorts is raised to a high degree. This is considered an important feature of the arrangement. The blast enters the chamber formed between the two cylinders, circulates around the retort, and passes up through the grate, and is carried out through a suitable flue leading to the main conduit. By taking advantage of the heat in the escaping gases to heat the delivered blast a marked decrease in the length of time necessary to melt a charge in the crucible is noticeable.

The details of this furnace have been well worked out, and while the general design of furnaces for this purpose must necessarily follow well-known lines, the design here presented commends itself as being a model which embodies many good ideas.

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LITTLETON'S GAS MOULD DRYER.

THE annexed illustration shows the Littleton Gas Mould Dryer, which is placed on the market by Mr. W. Littleton, of 9, Fenchurch Street, E.C. This particular illustration shows the dryer as arranged in a Midland foundry making hydraulic work. It will be noticed that the air and gas mains are carried along the side wall of the foundry with branch down pipes at suitable intervals; these down pipes are fitted with valves and union connections so as to be readily attached to the flexible pipes connected to the dryer, thus making a convenient system of air and gas supply which can be utilised at any part of the foundry floor. The apparatus consists of a powerful gas burner of the duplex air pressure type mounted in a strong cast iron casing with

LITTLETON'S GAS MOULD DRYER.

suitable flange to form base to rest upon in any position. Connections are arranged at convenient positions with unions by which the air and gas flexible pipes are attached. A small door is also provided to conveniently light the burner and a suitable outlet nozzle formed through which the heated gases are blown and connection made with the mould being dried.

The advantages claimed for this dryer are that after the apparatus is set up, the gas lighted, and air supply regulated, no further attention is required to replenish fuel, a uniform temperature can be relied upon for any desired length of time, and the risk of stoking operations sometimes carried out on a mould being dried avoided. As it is frequently necessary to blow into a mould in a horizontal direction, the gas dryer is most convenient for such positions, or at any angle desired, also either up or down.

The value of any tool or appliance, in a foundry especially, is proportional to the readiness or simplicity of application, and this is claimed for the gas dryer. The handiness of this dryer can be better understood when its weight is compared with coke dryers. No crane is required to place the gas dryer in position. A labourer can apply the apparatus without assistance.

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GAS PRODUCERS FOR POWER PURPOSES.

Far-sighted engineers, so far back as 20 years ago, ventured to predict that steam boilers some day would be superseded by gas producers. One well-known engineer, who is an authority in such matters, has not been afraid to boldly assert that in 50 years' time steam boilers will only be found in museums.

As might be supposed, the gas producer and gas engine has formed the subject of much controversy, and notwithstanding that the steam engine still has many ardent champions, gas engines and gas producers are nevertheless attracting more and more attention.

Dowson's gas producer, which has now been before the public for many years, was the particular apparatus that prompted these prophecies. With the aid of the Dowson plant, even at its inception it was possible to produce an effective horse-power hour with a trifle over 1 lb. of anthracite. The principle of the Dowson producer consists in forcing very hot air charged with a suitable quantity of steam, through a layer of incandescent anthracite. In this manner a mixture, generally called Dowson gas, is obtained which, as regards calorific power, holds a position midway between Siemens' gas and water gas.

The original Dowson gas plant consists —1. Of a generator containing the anthracite in a state of incandescence; 2. Of a small boiler designed for from 65 to 75 lbs. and capable of supplying steam; 3. Of an injector or blower which forces the mixture of hot air and steam through the grates; 4. Of a superheater for the air, which may either affect this before the current enters the injector, or may be made to warm the mixture of air and steam as it leaves the latter; 5. Of a box to eliminate the dust; 6. Of a purifier charged either with sawdust or oxide of iron for removing the tar, sulphur, etc.; 7. Of a scrubber or column of moistened coke, which retains the ammonia and the noxious gases which are easily dissolved in water; and 8. Of a gas-holder. With this plant, for every pound of anthracite, when about 1 lb. of steam is introduced with the air, from 70 to 80 cubic feet of mixed gas are obtained of the following average chemical composition:—Hydrogen 17, carbon monoxide (CO) 23, Marsh gas (CH_4) 2, nitrogen 52, carbonic acid (CO_2) 6 per cent., and traces of oxygen. Since designing the above plant Dowson has brought out a suction gas plant

The efficiency of a producer of this kind is 75 per cent., taking into account the production of the steam. The chemical reactions resulting in the production of the gas, and a comparative statement of the number of calories liberated by the incomplete combustion of the coal and of those absorbed by the decomposition of the water, have been fully dealt with in an excellent paper read nearly two years ago by Mr. Gerdes, before the German Engineers' Association. Amongst other facts this paper proves that the heat of the gases, which leave the generator at a temperature of 950 degrees Fah., is amply sufficient for evaporating and superheating the steam necessary for their production and for raising the temperature of the air which passes under the grate.

Though it is true that the Dowson producer has found numerous industrial applications, and, indeed, has become a standard of comparison, nevertheless, in the 30 years that have elapsed since the original was put on the market the number of plants, large as it is, has not been sufficient to limit to any serious extent the applications of the steam engine. It has, however, paved the way to the struggle

of the next few years. The future will teach us whether the gas or steam engine are destined to continue to develop side by side, or whether the former will eventually gain the upper hand. Both types of engine possess certain characteristics distinctly peculiar to each, and it will not be inappropriate if a short comparison of them is drawn.

The steam engine possesses the valuable property of being capable of an output, varying very much from the normal one, without any alteration worth mentioning in the economy of working. The guarantees as to the consumption of steam—which are given by many engine makers—apply to any duty ranging from one-half to the total horse-power, and, on the other hand, a great many steam engines are capable of developing an effective power double the nominal one at which they are sold.

The gas engine, on the contrary, works most economically at full load, consequently in cases where power is provided adequate for all eventualities, the expenses of working at ordinary times become relatively rather heavy, because the consumption increases with reduction of the power developed. It is admitted that a gas engine at half load consumes from 30 to 40 per cent. more than when working at full load.

With gas engines, the size affects only in a very trifling manner the consumption of gas or fuel per effective horse-power hour. One of 15 h.p. hardly consumes more in proportion per horse-power hour than one of 300 h.p.

With steam engines, on the contrary, the consumption of steam varies very considerably with the size. A good engine of 15 h.p. without condensation (which, indeed, with so small a size would have no practical utility) will consume 33 lbs. of steam per indicated horse-power per hour, whereas a compound engine of the Corliss type, of 300 h.p. with condensation, will consume only 12 lbs. Thanks to the employment of steam at a very high pressure (150 to 200 lbs. per square inch), and to the increase in the temperature by superheating it, the consumption per horse-power hour has been reduced to 9 lbs. According to information, one firm has lately given a guarantee of a consumption of 8.8 lbs. of superheated steam at a pressure of 160 lbs., and at a temperature of 350 degrees C. on entering the high-pressure cylinders, or 370 degrees C. on leaving the superheater. The engine in question is a triple expansion one of 1,200 h.p., of which the medium and low pressure cylinders are provided with a steam jacket. Further, in the same city there is another steam engine working, capable of developing 410 h.p., with a boiler having only 590 square feet of heating surface. These two cases appear marvellous, therefore they are given with all reserve. The figures cited, at any rate, will go to prove how valiantly the steam engine is defending itself in the battle with the gas engine. Superheated steam, still decried even in Germany, appears to have entered the domain of practical engineering, and certain German firms are actually supplying portable compound engines working with superheated steam, for which they guarantee a consumption of 1.36 lbs. of coal per horse-power hour.

Having related the triumphs achieved by superheated steam, we may briefly refer to some opinions expressed by leading Continental engineers who have had most experience of this mode of securing efficiency. M. Bollinckx, a leading Belgian engineer, expresses himself as follows (we quote his exact words): "The trifling saving effected by reheating the steam does not compensate for the extra expenses caused by the higher salary which must be paid to a skilful workman capable of taking charge of such a complicated installation, and for the extra cost of lubrication and the risk of accidents." More recently still M. Bollinckx has thus expressed himself: "In Germany, where the use of superheated steam is widely spread, its employment at a very high temperature is being abandoned. In Alsace—the cradle of superheated steam—engines working with it at an exceedingly high temperature (350 degrees C.) have never been in repute. Though the consumption of steam with engines of this type may be favourable, on the other hand its use at this high temperature is attended with serious drawbacks, such as the warping of the piston and of its rod, and the rapid wear of the superheater, etc. It may be possible, with care, to hide these defects during a trial which only lasts a few hours, but we think it would be difficult to obtain from the ordinary mechanic the special delicate attention requisite for an installation of this kind." This is, of course, only one opinion. Many others favourable to superheating could be cited.

If we pass on to steam engines of low power, in the immense majority of cases they leave much to be desired, for if some engines are fitted with a variable cut-off regulated by the governor, a steam jacket, clearance spaces reduced to a minimum, and particular care taken to render all the valves perfectly tight, there are a host of

others in the market of which the consumption of steam is something enormous. However, if we accept one of the lowest figures claimed by ordinary makers, 4½ lb. for small sized steam engines, and then take the highest estimate for producer gas, viz., 1.1 lb. of anthracite, a very appreciable advantage still remains, even if we take into account the difference in the prices of the fuel utilised—as a matter of fact underneath the grate of a boiler coal of all qualities can be burned, but the producer must be supplied with screened anthracite. In order to make clear the importance of the difference too frequently ignored in the cost of the respective fuels we will quote some figures given by Mr. Chas. Whitfield, of Kettering, the inventor of the Whitfield producer, of the cost per 100 h.p. per annum, using different types of motors :—

Tabulated Statement of Fuel, Consumption and Cost.

Type of Engine.	Kind of Fuel.	Price per Ton.	Consumption in lbs. per h.p. per hour.	Cost in Pence per h.p. per hour.	Cost per 100 h.p. per annum.
					£
Steam Engine. Compound	Ord. Coal	10s.	4	.214	210
Steam Engine. Simple	Ord. Coal	10s.	6	.322	362
Oil Engine. Otto Cycle	Petroleum	£5 10s.	.88	.518	583
Gas Engine. Consumption 18 cubic feet per h.p.	Town Gas	At 3s per 1000 cubic feet. =£9 10s.	.63	.61	720
Gas Engine with Non bituminous Producer Gas	Anthracite	21s.	1	.128	144
Ditto	Gas Coke	12s.	1.25	.08	90
High class Steam Engine	Ord. Coal	10s.	2 lb.	.107	120
Gas Engine with Producer Gas (187 B.T.U.)	Ord. Coal	10s.	.75	.04	45

The quality of the fuel utilised is important and merits our attention for a moment. In the producer, it is necessary that the fragments should be such as to offer a minimum resistance to the passage of the gases, while the pieces should present a maximum of surface to the same. The coal to be charged should be about the size of a walnut, free from dust, and it ought to be thoroughly well screened. Bituminous qualities yielding an agglutinated cohesive coke are quite unsuited for the purpose, because they obstruct the passage left free between the pieces of coal, and besides have the drawback of forming a scaffold or rigid arch, and consequently not descending gradually in proportion to the consumption; this would necessitate the constant poking of the fire and lead to great irregularities, followed by, perhaps, the fire being extinguished. Coals that decrepitate when burning are no better, for they soon choke up the airways with the dust they produce, and besides, the blast might carry the particles with it to such a degree as to obstruct the gas pipes. It is equally important to avoid the use of coal producing much cinder, for this would lead to the too rapid formation of slag and ash, which would make the operations of cleaning too frequent.

A coal too bituminous in character is attended with the drawback that the tarry products condense and settle on the valves, much soot is deposited, the piston rings may become damaged, and the valves be partially choked up. The volatile matter may also condense in the elbow of the gas pipes and cause an obstruction. In short, the fuel for the producer must be a non-bituminous anthracite coal, non-cohesive, containing little tar, producing not much cinder, and the smalls and the slack must be removed by carefully screening it. The best known varieties of coal for the manufacture of producer gas are the anthracites of Wales and Pennsylvania, which contain about 92 per cent. of fixed carbon, 2 per cent. of water, and from 2 to 4 per cent. of ash. Of course, many experiments have been made to burn other kinds of coals in gas producers, but excepting by the aid of the washing and cleaning plants used by Duff, Mond, Whitfield, and others, up to the present they have not been crowned with success. On the Continent, a Lencauchez producer with blast is said, with English non-coking coal, to yield a gas of uniform composition, and the Gasmotorenfabrik, of Deutz, supplies producers for which lignite coal containing as much as 60 per cent. water can be used. A French engineer, M. Genty, has invented a gas producer of which, in regard to this point, sanguine hopes are entertained. A Belgian engineer, M. L. Bemelmans, has designed a producer with a revolving grate, which constitutes a sort of mill, the purpose of which is to break up the cinders, and thus is said to allow of the use of bituminous coal. Finally, the Société Cockerill is at the present time working on a producer in which the ordinary varieties of coal may be burned.

The question of the supply of water

may at times tell forcibly in favour of the engine driven by producer gas. A plant of this kind does not require more than from 6½ to 9 gallons of water per horse-power hour, and the quality is of no importance. Besides, the quantity of water necessary for cooling the cylinder may be considerably reduced by the employment of a reservoir constituting a thermo-syphon. A steam engine working with condensation requires five times this amount, and in addition the water used in the boiler must be of a suitable kind and not produce too much scale or incrustation. We will not dwell for long upon the question of regularity in working. It is at once evident that owing to its principle of action the steam-engine is more uniform than the single-acting four-cycle gas engine. This question has, however, lost much of its importance since experience has proved that by the introduction of a heavy flywheel on to the gas engine, a regularity of working sufficient for electric lighting could be secured.

Quite recently several firms, including the Deutz Company, have ventured to couple in parallel three-phase dynamos, driven by gas engines, and the most complete success has attended this exceedingly bold step.

The gas engine driven by producer gas has been reproached with the necessity of being regulated by hand when variations in the load occur, and with producers with blast the difficulty of cleaning them while in operation has been urged. These drawbacks have been overcome, and nowadays producers are made which work continuously and automatically, no matter what may be the fluctuations in the load In the case of the producer with closed grates, gases escaping from leakages may injure the workmen. These gases, we may add, not only emit a disagreeable odour, but have a poisonous effect. Down to comparatively recent years producer gas engines have not been adopted to the extent that their economy in working would seem to warrant, which is to be attributed to the gas producer. With gas engines of from 6 to 60 h.p., for example, the only producer available was the Dowson, and in the early days the cost was relatively rather high.

Further, it is now possible to make gas producers more simple, less expensive, less cumbersome, more easy to attend to, with the cost of maintenance reduced, and—most important of all—capable of burning the small coke supplied by gas works. These improvements have been due to Dowson, Whitfield, Bowman, Crossley, and a host of other inventors.

We have now to consider the case of steam engines of large power with which, as already stated, by employing highly superheated steam at a high pressure, and with the introduction of a superheater for the water after the type of Green's economiser, the indicated horse-power hour can be produced by the expenditure of 1.25 lb. of coal valued, at the present moment, say, at 10s. a ton. The question arises: Is there any justification for these very powerful steam engines? In the author's opinion, electrical power stations are not in many cases really justifiable considering the extreme facility with which the transmission of gas to a distance can be effected and distributed without any appreciable loss of energy, and likewise, the extraordinary economy in working that distinguishes gas engines of small size.

Gas can be conveyed a distance of several miles without incurring a loss of energy greater than ¼ per cent. A pipe 6 in. in diameter will convey the quantity of gas required by an engine of 300 h.p. It is true that in certain cases the advantages of electricity are overwhelming. It is the most practical method of producing light for industrial purposes. For traction, the working of hoisting apparatus, and for many other purposes, the electric motor is characterised by such prominent qualities on account of its excellent behaviour at starting and under a possible overload, and the ease with which the speed can be varied and the direction reversed, that the expediency of its adoption cannot be questioned. Three-phase electric currents of high potential are admirably adapted for the transmission of motive power for long distances, and for a very extended distribution of the same. These advantages, however, are only obtained at the cost of a succession of losses of energy which, added together, lead to a final efficiency very much less than is generally supposed. In point of fact, if we assume the most favourable conditions and suppose :—

	Per cent.
The efficiency of the steam engine	92
The efficiency of the generating dynamo ...	92
The efficiency of electrical conductors ..	95
The efficiency of motors	88

we shall obtain for the ultimate real efficiency 92 by 92 by 95 by 88—70 per cent., or a loss of 30 per cent.

The distribution of energy gas appears to be not only more economical in working, but the first cost of the plant is in addi-

tion very considerably lower. This plan cannot be said to be novel, for since 1882 all the motive power of the large works of Messrs. Crossley, at Openshaw, has been produced by Dowson's gas. The vast establishments of the Gasmotorenfabrik, at Deutz, are equipped with 144 gas engines, with an output of about 1,300 h.p.

The plan adopted at the locomotive works of the Société Suisse, at Winterthur, appears to have much to be said in its favour, compared with that of distributing electrical power from a station. This firm has erected in a central position at their works a battery of producers of the Dowson type, which supply the gas to a dozen different engines driving the machinery of the various departments of the establishment, the requirements of which are about 700 h.p. Amongst these 12 gas engines there is no one more powerful than the rest which works a dynamo, furnishing the current for the electric lighting and that necessary for the travelling and stationary cranes, the portable machine tools, etc. By adopting this plan all intermediary losses are suppressed, the producer gas is conveyed without any appreciable loss, and the power is consumed at the spot where it is produced.

It was desirable that small concerns, as well as large ones, should be able to benefit by the advantages attending producer gas in the production of motive power. The difficulty that presented itself was to find a producer at one and the same time sufficiently cheap, not too bulky, easy to erect and work, and perfectly safe, which could be connected up to a small size gas engine without the cost of the installation exceeding that of a steam engine and boiler. This problem has been solved by the simplification of the producer by the automatic devices of Whitfield and others, and by the invention of the gas producer, worked automatically by the exhaust action of the engine or "suction producers," as they are called. The feature which distinguishes the suction producer most is the absence of the boiler and gasholder. The engine itself sucks in the gas and the mixture of air and steam required for its production.

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TAYLOR BROS. & COMPANY, LIMITED, is the name of a company formed to acquire the business carried on at the Clarence Iron and Steel Works, Hunslet, Leeds, Yorkshire, under the style of Taylor Bros. & Company. The capital of the concern is £200,000 in £1 shares.

THE STEEL CASTING INDUSTRY OF SHEFFIELD.

SHEFFIELD is by far the most important city in the world from the steel caster's point of view. It is no exaggeration to say that the volume and weight of steel castings turned out by Sheffield in a year far exceeds that of any other city in the world. There are numerous establishments devoted to the manufacture of steel castings by the crucible, open-hearth, Tropenas, and Robert processes, and as the recent visit of the Iron and Steel Institute has resulted in a number of these establishments being thrown open for inspection, we propose to briefly touch upon the most interesting features shown in connection with a few of the firms.

At the extensive works of Messrs. William Jessop & Sons, Limited, Brightside, Sheffield, steel for various purposes —large and small work—is turned out, but the Company make a feature of crucible steel for tools of all kinds. Started in 1774, the firm have succeeded in securing and maintaining a well-deserved reputation.

In the making of tool steel much depends on the careful selection of raw material, on the judicious proportioning of ingredients according to the special quality of steel required to serve the particular purpose of the individual customer, on the extreme care with which the processes of melting and annealing are gone through, and on the stringent final tests and examinations which do not allow even the slightest imperfection to pass undetected.

Coming to the Brightside Works, the records of the firm go as far back as the year 1774, and the work done represents the accumulated knowledge and skill of a century and a quarter. The original founder of the firm was the first William Jessop, from whom the works passed into the possession of his sons, Thomas, Sidney, and Henry. In January, 1876, the concern was changed into a limited liability company, the present chairman of which is Mr. J. E. Cutler. The other directors are Mr. A. J. Hobson, Colonel H. Hughes, C.M.G., Mr. Alfred Hills, and Mr. Sydney Jessop Robinson, the latter being managing director. Mr. Robinson is a great-grandson of the founder. The works were first set up in Sheffield itself. About 80 years ago, however, they were removed to Brightside, then a pleasant country place, but now presenting an almost unbroken series of

industrial establishments, mostly of great magnitude, for a distance of some two or three miles from the city. By reason of the fact that the Jessop Steel Works were the first to be set up in a locality where such firms as Messrs. Vickers, Sons & Maxim, John Brown & Company, Cammell Laird & Company, and others have followed, they have become known as *the* "Brightside Works."

Such, too, has been their growth that they now cover an area of 40 acres, intersected by the River Don, to the "water rights" of which the firm have the claim for a distance of over a mile. A bridge across the river puts the two sections of the works in communication the one with the other. Among other plant the works have open-hearth furnaces, each of from 20 to 25 tons capacity; 21 crucible

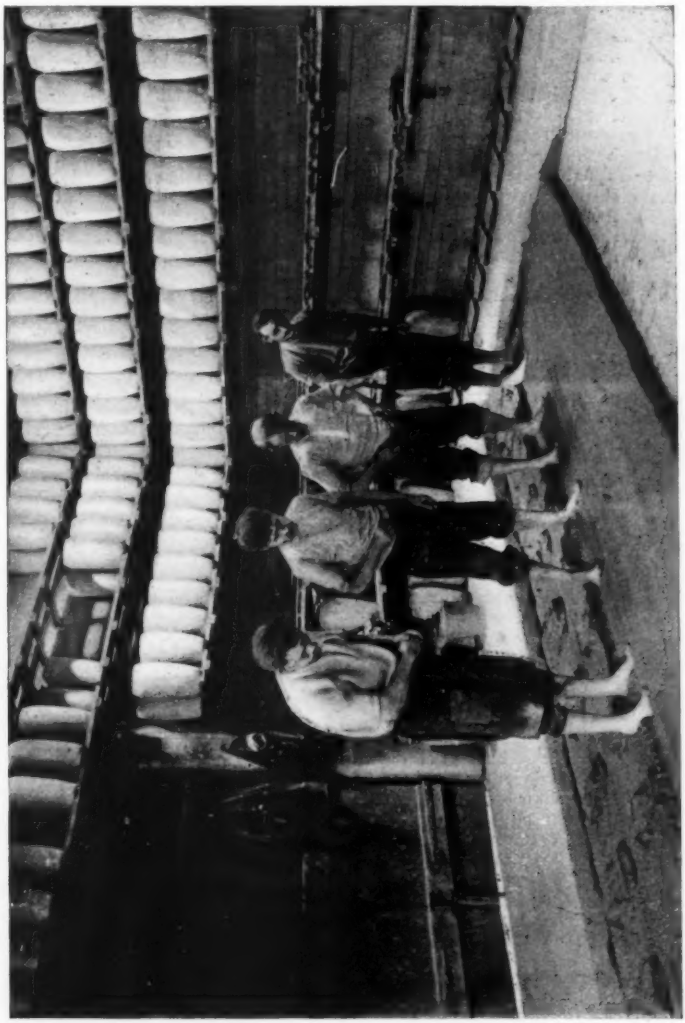

FIG. 1.—"TREADING" CLAY FOR CRUCIBLES; JESSOP & SONS, LTD.

furnaces, each furnace with 12 melting holes, and each hole capable of heating, by coke fire, two crucibles in the three meltings per day, besides 12 melting holes of six pots each, worked by "producer gas" (made on the premises), and capable of dealing with 72 crucibles per day; four Siemens furnaces; 31 boilers, representing 3,000 h.p.; and two generators for producing electric light and electric power, besides generators for the electric welding plant. To facilitate operations five miles of railway lines have been laid down in the works, and there are three locomotives constantly employed in drawing the wagons used for conveying material, etc., to the various departments, and in transferring the finished articles from the firm's sidings to the various railway companies for

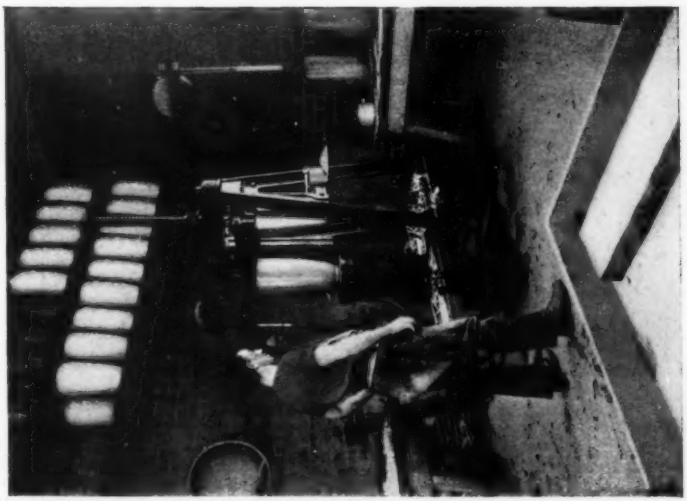

FIG. 3.—CRUCIBLE-MAKING MACHINE.

FIG. 2.—CRUCIBLE MAKING. THROWING THE CLAY.
JESSOP & SONS, LTD.

despatch to all parts of the world. There are, also, three locomotive cranes with a lifting capacity up to 25 tons, and some overhead and stationary cranes up to 100 tons capacity. The number of men employed in the works is about 1,500. The annual consumption of coal and coke is 80,000 tons, and the annual production is from 8,000 to 10,000 tons of crucible steel and 22,000 tons of open-hearth steel.

The uses to which "Jessop steel" are put are almost without limit. The firm were the first in the world to produce cast-steel rams for battleships. They were also the first to produce steel rudder frames, stern frames, and propeller brackets made in a single piece. For naval castings and forgings of this type the firm are contractors for the British Admiralty, and also for Russia, Spain,

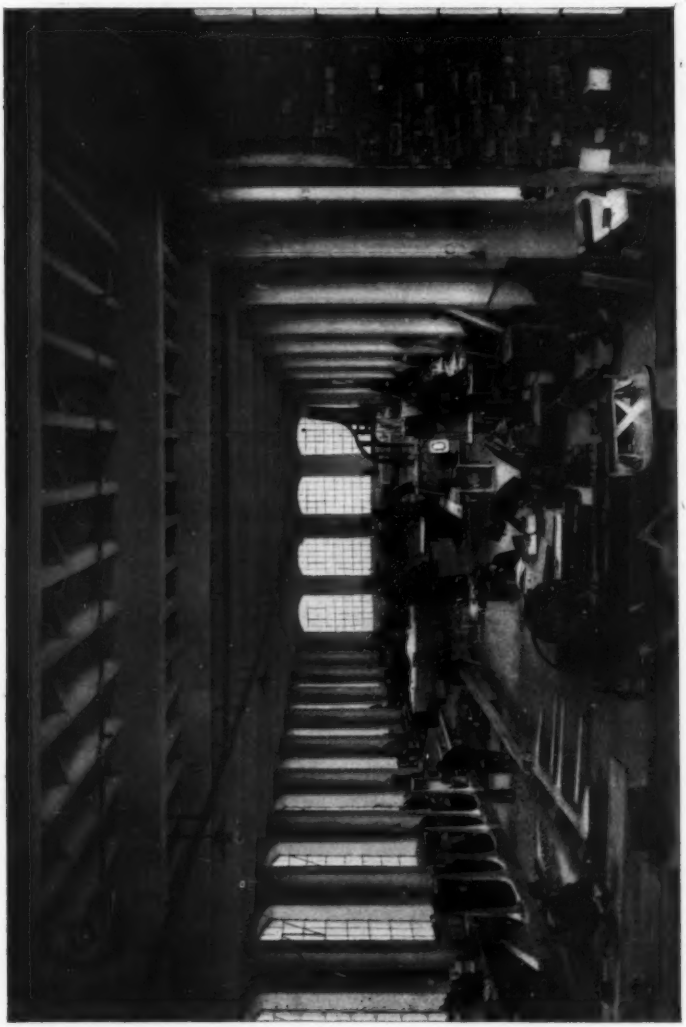

FIG. 4.—THE PATTERN SHOP; JESSOP & SONS, LTD.

and Japan. But the arts of peace are provided for no less effectually than the arts of war.

Much of the quality of Jessop steel is dependent on the use of the best brands of Swedish iron. The Company import 8,000 tons of it in the course of a year.

The "conversion" of the bars of Swedish iron into "blister steel" is effected by means of furnaces where they are embedded in charcoal in long troughs, the end of the furnaces being then sealed up with sand. The furnace fires are kept burning for a period of 14 days, during which time the iron absorbs carbon from the charcoal and is changed into steel, the term "blister" being applied to it on account of the "blisters" which appear on the surface of the bars. These are left in the furnaces for a further period to

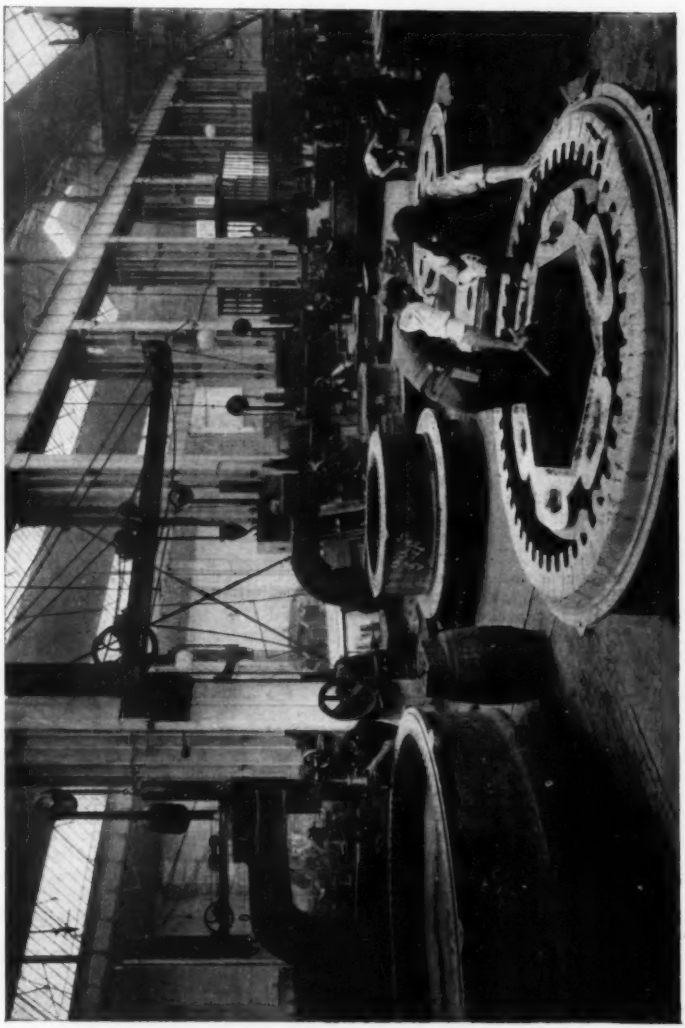

FIG. 5.—STEEL FOUNDRY, SHOWING MOULDING MACHINES; JESSOP & SONS, LTD.

cool down, and they are then removed from the furnaces and broken into small pieces in readiness for the melting department. Such pieces of blister steel form the basis of the ingredients put in the crucibles for the production of the qualities of steel desired for various purposes.

The making of the crucibles in which the various ingredients are melted together is an interesting process. Different kinds of clay and old crucibles ground down into powder are mixed in certain proportions with water in a large trough, and kneaded together for several hours by men working with their feet. The stuff is then cut into lumps of a specified weight, and worked by hand on a table so as to release any imprisoned air. After this the lump is dropped into a steel mould, or "flask," and a plug is driven down upon it by a press worked by hand. The clay thus receives the form and thickness of the crucible required. Removed from the mould, it is left to become perfectly dry and hard, and in that condition it should stand the fiercest of fires. It can be used several times over provided it is not allowed to get cool, and the crucibles with which the men start afresh each morning are used for the three meltings which take place during the day; but as soon as the crucibles cool they crack and cannot be put in the fire again. When cracked, however, their career is not ended, for, when ground down, the powder can be used, in a certain proportion, in the making of fresh crucibles, the moulding of steel castings, and other purposes.

The contents of a single crucible suffice to form an ingot of small size, but at Brightside Works an interesting operation is seen when 48 crucibles are used in the making of a casting about one ton and a-half in weight. This is done in a furnace provided with 48 holes in four sets of 12 each. The casting of the piece is carried on in the centre of the furnace, and 12 holes on each side are taken, so that the pourers-out can advance with their crucibles diagonally and maintain a regular procession until the operation is over, two crucibles being drawn from each of the 24 holes utilised. The mould in which the piece is cast is sunk into a hollow in the floor, across which gratings are placed, but the metal is first poured into a heavy iron "ladle," provided at the bottom with a tube through which the molten metal will flow into the mould on the withdrawal of a plug worked by a lever. To begin with, this ladle is placed upside down over a coke fire through which a powerful blast of air is driven into the ladle by an electric fan, the ladle thus acquiring a red heat. When all is ready for the operation, the ladle is raised by an electric crane, turned over, and then carried along until the funnel is directly over the mould, into which it is lowered, the top of the ladle being left just above the level of the floor of the melting furnace. Then, on each of the two sides of the furnace, working diagonally to one another, as already indicated, the men pull aside the lid of each hole, and draw out the glowing crucibles, one after the other. Each crucible is seized by a man who is provided with a pair of tongs fitted on to wheels, so that the crucible can be both held firmly and wheeled along easily to the edge of the ladle. Arrived there, the man tilts the crucible over the top of the ladle, and the liquid metal flows into the ladle, with a shower of sparks. So the men advance in steady succession from opposite sides, emptying their crucibles, and then passing on so as not to impede the movements of those immediately behind them. Soon the ladle begins to fill up, presenting the appearance of a cauldron of molten gold, while all around there is spread a terrible heat, against which the workers protect their legs by fastening wet sacking over their clothing. When the last of the 48 crucibles has been emptied into the ladle, the plug is drawn up, and the metal then runs down in a steady stream into the mould, the funnel being so arranged that the metal falls straight to the bottom of the mould without first touching the sides. So perfect is the organisation that the whole operation will have lasted only four minutes.

The Siemens process is now used at the Brightside Works in the production of steel in large quantities, either for ingots, from which are produced forgings weighing from 10 cwts. up to 30 or 40 tons, or for direct castings for railway wheels, battleship rams, stern frames for steamships, and so on. Of the four furnaces in use two are of 15 tons capacity, one of 25 tons, and one of 50 cwts. An exceedingly interesting process is that of electric welding. Sometimes there will be slight imperfections in the castings, such as holes or indentations that require filling in. This is done by the process of electric welding, which, by those previously unacquainted with it, will be regarded as one of the most interesting sights afforded at Brightside Works. The operator holds in his right hand a tool through one end of which an electric cable passes, while through the other end,

at right angles, there is fixed a piece of carbon such as that used in an ordinary arc lamp. The other cable is attached to the steel casting to be operated on. The completion of the circuit causes not only a powerful light to appear, but the generation also of intense heat between the carbon and the part of the steel casting near to which it is held. So powerful is this light that to look at it with the naked eye would cause intense pain in the eyes after the lapse of some hours. The operator, therefore, wears over his head a wooden box fitted with a window of red glass, while a visitor is provided with a framed piece of red glass, through which alone he is warned to look. Such is the degree of heat produced by the electric current that within a few seconds the steel through which it passes is not only melted but brought, apparently, to boiling point; and when another piece of steel is put alongside it also melts rapidly. By so melting and mixing with the already molten steel or casting it fills up the hole, and thus the imperfection is got rid of. The precise amount of heat generated in the process of electric welding is not known, but it must be over 2,500 degrees Centigrade.

We will conclude with a reference to the laboratories of the Company, which consist of two sections, the chemical and the physical. In the former of these the practical experience of a century and a quarter of workers in the art of steel making is supplemented by the scientific tests, experiments, and general guidance of the chemist and his assistants, whose function it is to analyse all the raw materials received and all the steel produced from them. It is in conjunction with the chemist that the all-important question of the choice of ingredients and the quantities thereof for particular qualities of steel is often decided, while he must share the responsibility of seeing that the precise qualities are actually secured. In many cases the consumers will specify the analysis which the steel they order is to show, and here, of course, the chemist has to satisfy himself that the requirements have been fulfilled.

FIG. 6.—STEEL FOUNDRY (INTERIOR); JESSOP & SONS, LTD.

The special province of the physical department is to see that the mechanical tests imposed by the various Governments, railway companies, or others who have sent in their orders can be satisfactorily met. One test is for "tensile stress." Having first been placed in a lathe, and reduced for a certain distance to a specified circumference, the piece of steel is put in a machine which pulls it into two pieces. The amount of force required to produce this result is registered on the machine, while the amount

of elongation that has taken place before the steel gives way, and the exact circumference at the breaking point, must also be according to specification. Then there is a bending test, in which the steel is put under a hydraulic press, and note is taken of the angle to which it can be bent without fracture.

The physical laboratory is also equipped with all necessary apparatus for the microscopical examination of steel, a method which was initiated by a Sheffield

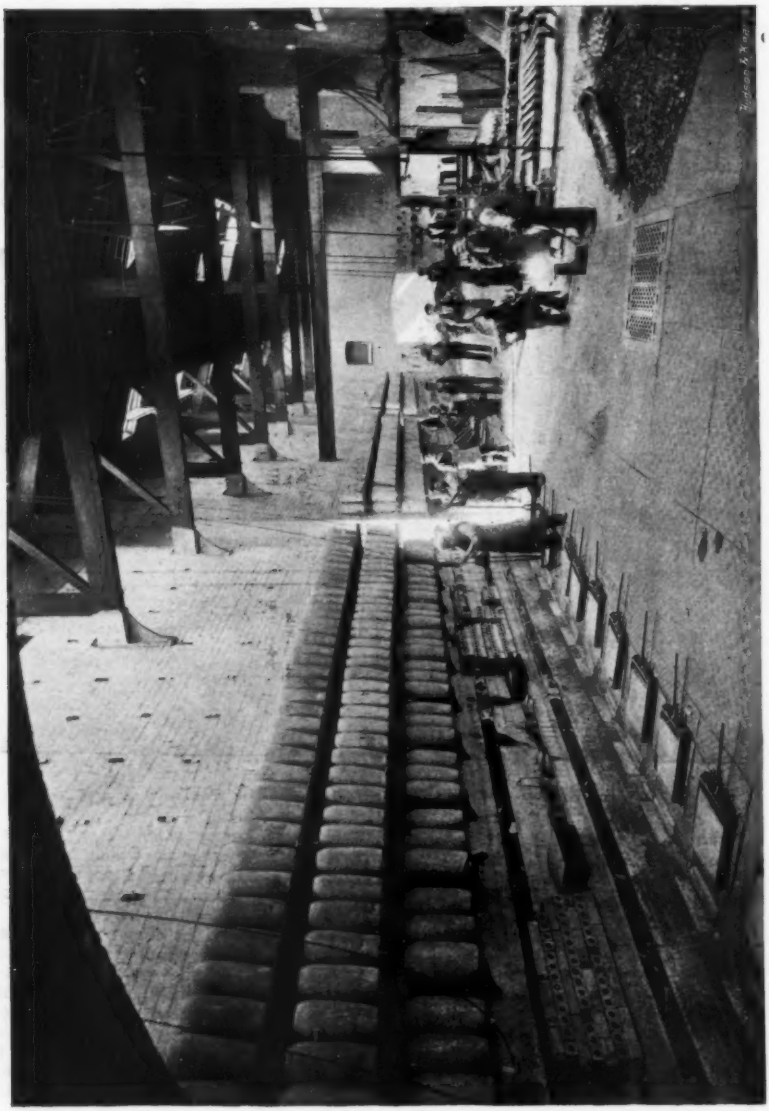

FIG. 7.—SOME OF THE CRUCIBLE CAST STEEL MELTING FURNACES; SAMUEL OSBORN & CO.

man, Dr. H. C. Sorby, F.R.S., and now fills an important position in the metallurgy of steel.

The premises of Messrs. Samuel Osborn & Company, which are known as the Clyde Steel and Iron Works, constitute a typical Sheffield manufactory, and occupy a foremost place in the ranks of the best houses engaged in the staple industry of that centre. The forge, the crucible cast steel melting furnaces, the rolling mills, the spring fitting and testing shops, the Siemens-Martin furnaces, the steel moulding shops, and other of the departments and plant, are well worth inspection, and some of the specialities produced by the firm are of particular interest at the present time, when the developments in connection with the use of high-speed tool steels are

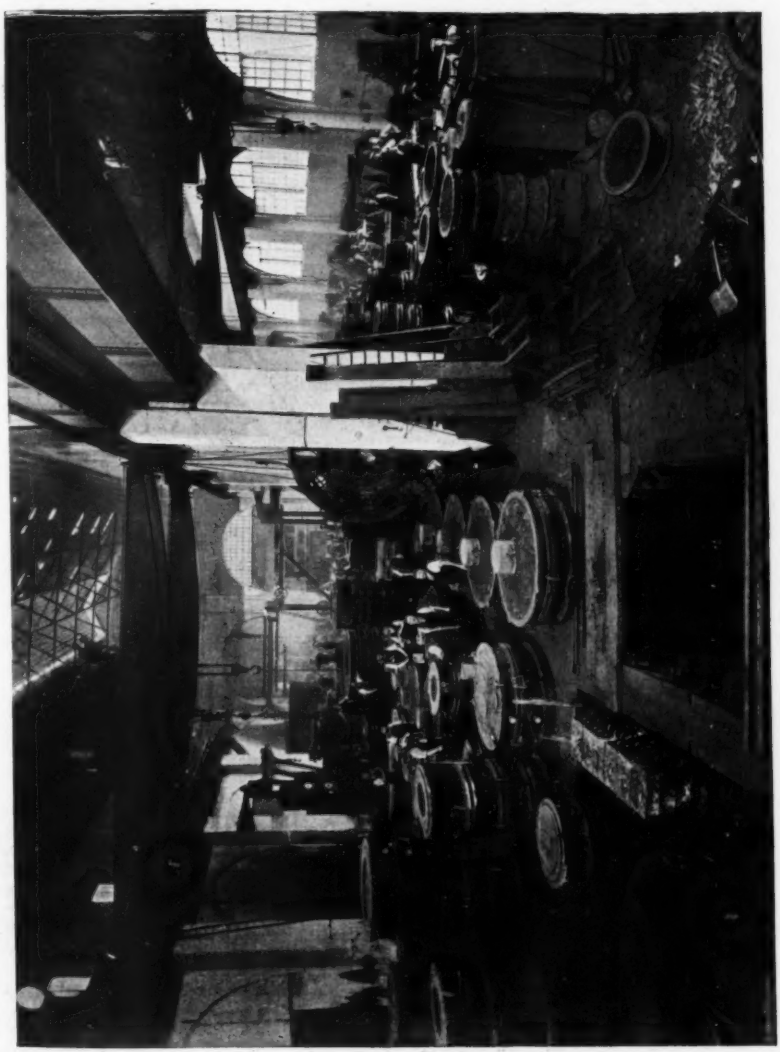

FIG. 8.—STEEL MOULDING SHOPS; SAMUEL OSBORN & CO.

being watched with close attention throughout the trade. Messrs. Osborn's name has been prominently associated with Mushet's process for the past 30 years. They adopted it some 30 years ago, and it has gradually been improved to meet modern requirements until at the present time it is recognised as one of the best high-speed steels of to-day for turning tools, twist drills, milling cutters, and other similar implements. The following tests were shown to members of the Iron and Steel Institute :—

On the 16-*inch Testing Lathe.*

Material operated upon.	Feet per minute	Feed.	Cut off diameter.	Size of tool.
		Inches.	Inches.	
Siemens-Martin forging	60 to 65	¼	1	1¼in sq.
Do. (32 tons tensile)	Do.	¼	½	1¼ ,,

On the New Tangye Drilling Machine.

Material operated upon.	Revolutions per minute.	Feed per minute.	Size of drill.
		Inches.	Inches.
Siemens-Martin acid steel billet	111	3.58	2½
Do	181	5.85	1½
Do.	269	6.99	⅝
Do	376	9.74	¾
Cast iron	526	17.02	¼

Tests made with "Mushet" High-Speed Steel.

Material operated upon.	Feet per minute	Feed.	Cut off dia meter.	Size of tool.
		Inches.	Inches.	
Hard steel (Siemens-Martin)	110	⅛	⅜	1 in. sq.
Very hard steel ..	90	1/16	⅜	1¼ ,,
Siemens-Martin forging	66	¼	1½	1¼ ,,
Cast iron	90	⅛	¼	1¼ ,,
Very hardest cast iron procurable	35	1/16	½	1¼ ,,

The firm have put down quite recently a new plant for the production of drills which embodies the latest and best features of American and Continental practice, while several tools already in the works have been adapted for the making of milling cutters. The introduction of high-speed steel has been remarkable no less for the revolution it has brought about in machine-tool design than for the improvements it has rendered possible in workshop practice. Lathes and drilling machines have been completely remodelled. Messrs. Osborn are of opinion that cold-sawing machines are likely soon to be similarly modified, as they have proved in their own steel foundry, where cold-saws made from large circular plates of Mushet high-speed steel have been most successfully used.

Messrs. Osborn & Company were the pioneers of self or air hardening steel, and they are still the sole manufacturers of the Mushet quality. Among the firm's numerous productions are toughened cast steel castings, and in this connection it is interesting to note that steel gearing made by them was used on the steamers conveying the Russian troops across Lake Baikal.

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HOT- v. COLD-BLAST IRON.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I notice that in your JOURNAL for September, I am reported as saying at the Glasgow meeting of foundrymen that cold-blast iron is distinctly inferior to hot-blast iron.

This is not correct. The cold-blast pig-iron of South Staffordshire is, in my opinion, one of the finest in the world for the very special purposes for which it is used.

The hot-blast iron (all-mine) is made from somewhat similar materials with hot-blast, and is not so good for the special purposes for which cold-blast is used.

Perhaps you will kindly make this correction.

Yours etc.,
HERBERT PILKINGTON.

Chesterfield, September 29, 1905.

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THE ALLIANCE WORKS, better known as the Wheel and Axle Works, Darlington, which formed part of the Darlington Wagon and Engineering Company's Works, have been sold to a syndicate composed of Mr. Blake, Middlesbrough, Mr. J. W. Richardson, Darlington, Mr. R. Blaylock, Mr. J. Banks, Mr. T. Richardson, and others.

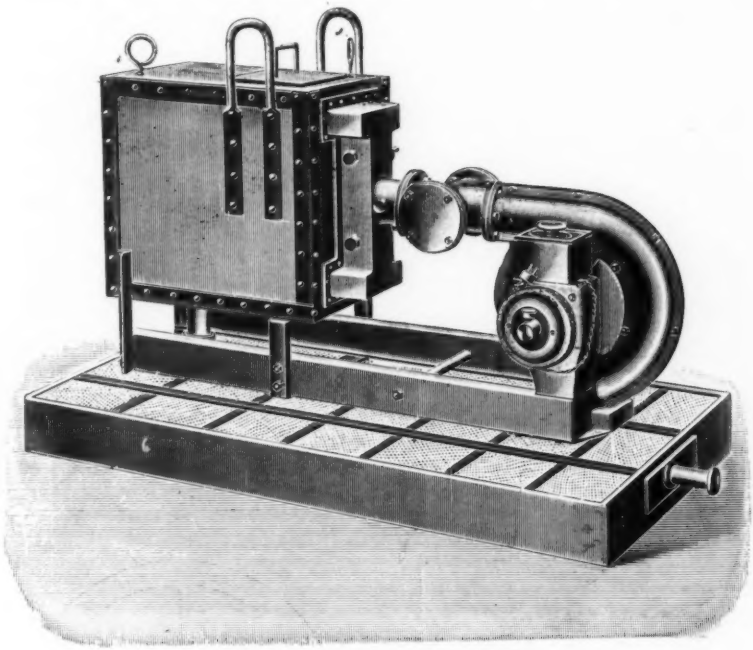
THE Associated Iron and Steel Makers of West Cumberland have come to an agreement with the North-Eastern Railway and other coke-carrying railways from the East Coast, whereby the question of rebate is solved by the companies reducing rates on coke to an extent which is equivalent to the amount of rebate previously allowed.

THE JACKMAN PORTABLE MOULD DRYER.

This dryer has been designed for quickly and thoroughly drying large moulds on the foundry floor. It is readily portable, and operated at small cost of fuel. The dryer is shown below. It contains three compartments, namely, air-regulating chamber, fire box, and hot-air chamber. In the air-regulating chamber there are two butterfly dampers, by which the flow of air is regulated so that a portion of the air is forced under the grate bars and through the fire, thus increasing its intensity, while the balance of the air flows over the fire, mixes with the products of combustion, and passes into the hot-air chamber, and thence through a short pipe into the mould.

The air supply is furnished by a small Buffalo "B" Volume Blower, which may be direct connected with the dryer, if desired; it is preferable, however, to use a stationary blower, and instal a line of 6-in. air pipe along the foundry with branches to the points where the dryer will be used. An air pressure of 2 to 3 ozs. is all that is necessary. For successful mould drying it is necessary to provide an outlet from the mould at the lowest point to carry off the moisture. The Jackman portable mould dryer is made in the following sizes:—

No.	Length. in.	Width. in.	Height. in.	Weight unlined. cwt.	Weight lined. cwt.
1	40	25	27	5	7½
2	30	21	24	3	5
3	22	16	20	3	3



Jackman Portable Mould Dryer.

We are indebted to Messrs. J. W. Jackman & Company, of 39, Victoria Street, S.W., for the above particulars.

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Mr. P. F. Thompson has retired from the firm of J. Thompson & Company, mechanical engineers, London, S.E.

Macfarlane, Strang & Company, Limited, Lochburn Iron Works, Glasgow, are supplying 960 tons of cast-iron pipes of 18 in. to 36 in. diameter, and 1,230 tons of 24 in. diameter, to the Glasgow Corporation Water Committee.

CASTING A CHILLED FACING RING FOR EDGE RUNNERS.*

THE ring to be cast (A. Fig. 1) has an outside diameter of 72 in., a breadth of 20 in., and a thickness of 6 in. The outer

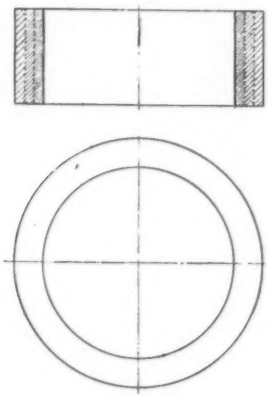

FIG. 1.

surface or face is to be glass hard for a depth of about 2 in., in order to minimise wear during use, whilst the inner surface is to be workable, and therefore of fine to coarse grain. The hardened face is obtained by employing the cast-iron chill mould (Fig. 2), the walls of which are 4¾ in. thick, the liquid iron coming in contact with the mould being cooled down very rapidly so as to prevent the formation of graphite. To prevent the cracking of the mould, it is surrounded by two wrought iron hoops, C, which, however, must not be shrunk on, but are made large enough to have about ½ in. play all round, and are held in place by four loosely driven wedges, D, so that they can expand or contract freely. If the hoops were tight against the mould they would crack under the expansion of the mould, and thus be powerless to prevent fracture of the mould itself. The mould is built up in the following manner: A bottom plate, E, shown in Fig. 3, is cast in an open mould, and is provided with a footstep bearing for the moulding spindle, and with a feather. This latter is turned to fit a corresponding rebate turned in the lower

* From "Stahl und Eisen."

inside face of the chill mould, the two thus forming a tight joint for casting. The plate is also provided with four lugs, for carrying, and these are holed for the reception of the tie bolts holding the finished mould together. The moulding

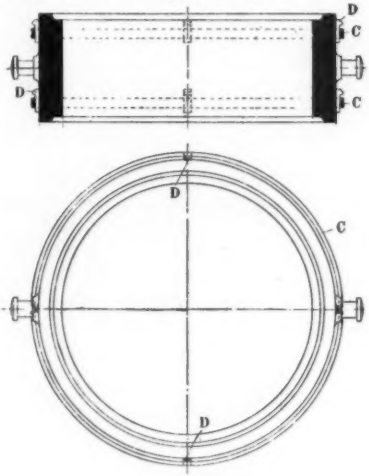

FIG. 2.

spindle, G (Fig. 4) having been inserted in the footstep bearing on the bottom plate, and the shaper, H, held by the

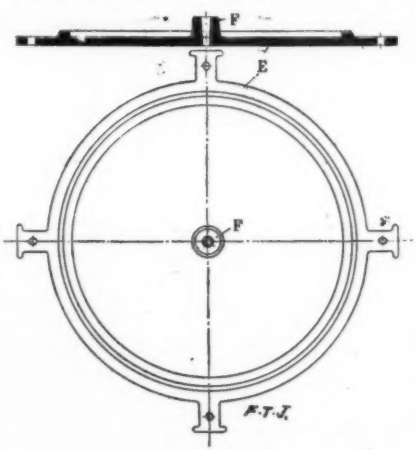

FIG. 3.

cross-arm, J, has been attached, a commencement is made with the building up of the core, K, which is ½-brick thick and

contains several loam bricks in each course. A layer of straw is arranged radially on the bottom plate, to permit the escape of air. After the core has been built up to a height of about 20 inches,

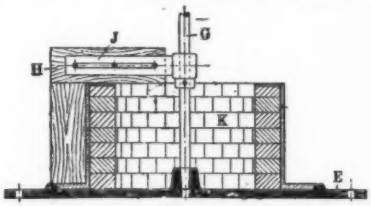

FIG. 4.

the outer face is coated with a layer of loam, about four-fifths of an inch thick, this being levelled by the shaper, whereupon the shaper and spindle are removed, and the core is dried and blacked. The cover plate, E^1 (Fig. 5), which is also provided with a feather turned to fit a rebate in the chill mould B, is next coated on the under side with a layer of loam, which is levelled off flush with the projecting edge of the feather, provision being made, with a layer of straw, for the escape of air. This plate is also cast in an open mould, and in addition to the bolt holes in the lugs, is provided with a hole L, for venting, and holes M, for filling the mould.

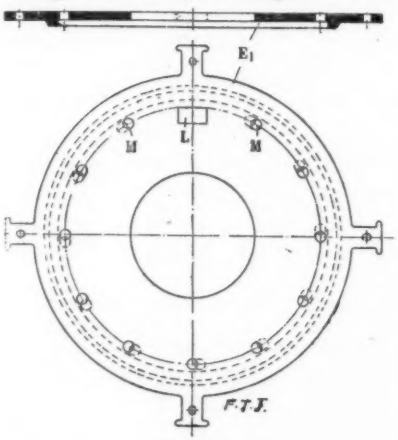

FIG. 5.

All these holes are lined with a thin coating of loam. With regard to the 11 casting holes, it should be noted that, instead of being vertical, they are sloped at an angle of 45 degrees with the plane of the plate. When the cover plate has been dried and blacked, the mould is put together. For this purpose. the bottom plate E, and core, are mounted on a couple of beams N (Fig. 6), and over them is placed the outer chill mould B, which has been faced inside. Over all is laid the cover plate E^1, and the parts are fastened together by means of the four tie bolts O, a fifth bolt O^1, being passed through the footstep bearing on the bottom plate,

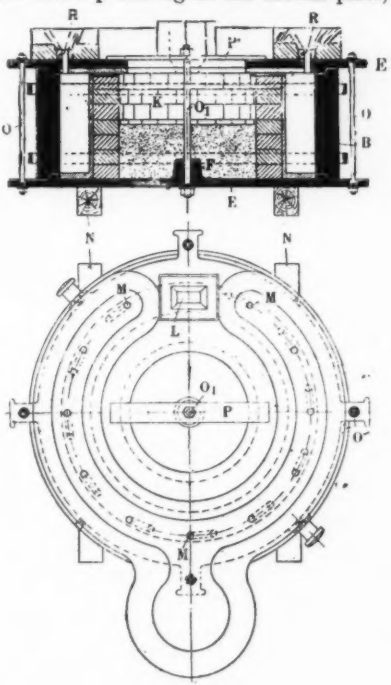

FIG. 6.

and attached to the cover by a fishplate L. The core is then half-filled with rammed sand, and the casting trough M, and vent L, are made. The latter measures about $4\frac{3}{4}$ by $2\frac{1}{4}$ in. at the bottom and $6\frac{1}{4}$ by $4\frac{3}{4}$ in. at the mouth. Over the pouring holes in the cover plate are placed a number of specially made core blocks R (Fig. 6), fitted with $1\frac{1}{8}$ in. bores, which form a continuation of the holes in the cover, and like them are sloped at an angle of 45 degrees. The holes, too, are set in such a position that the iron entering the mould is delivered close up to the chilling ring; and the slope of the holes imparts a rotary motion to the molten metal, so as to drive any slag or other impurities towards the central core, where they settle down and do no harm.

POWER DISTRIBUTION IN THE CLYDE VALLEY.

Those members of the British Foundrymen's Association who visited Glasgow for the Convention in August, in addition to seeing one of the most economically administered municipalities in the world, found that electrical power is making great progress across the Tweed. In the Clyde Valley particularly there has recently been started a power distribution scheme which has for its object the supply of electrical energy for manufacturing purposes, and has obtained powers over an area extending along the Clyde Valley from Craigendoran and Port Glasgow on the west to Lanark and Shotts on the east. This area, which comprises about 750 square miles, contains the most important manufacturing district in Scotland. The Company—the Clyde Valley Power Company—are erecting two power stations. The station at Yoker was formally opened in June, while the Motherwell station is well advanced towards completion. In addition to the generating stations, the Company have also in hand the laying of a comprehensive system of mains and the erection of a number of transforming stations, which are situated at the most convenient points for serving the largest number of users of electrical energy.

The engine room consists of two floors, all the auxiliaries being in the basement with the exception of the exciting dynamos. The main generating plant, as at present installed, consists of two Westinghouse-Parsons steam turbines, each with a normal capacity of 3,000 h.p. and an overload capacity of 3,750 h.p.

Each of the above turbines is directly connected to a 3,000 h.p. generator, which generates electric current at a pressure of 11,000 volts, three-phase, at 25 periods per second. This is the pressure at which current is distributed to the various substations. In a short time the cables will be in, ready for supplying power to any part of the district between Clydebank, Scotstoun, and Temple. These cables are all laid in duplicate, in case of accident.

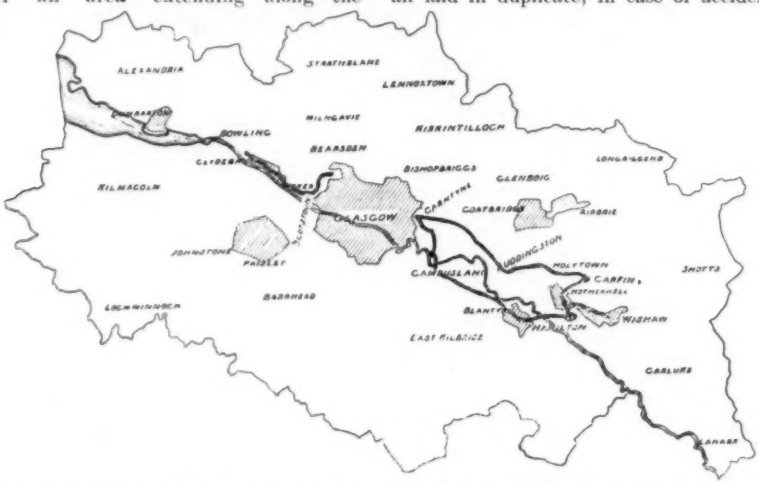

Fig. 1.—Diagram Showing the Clyde Valley Electrical Power Company's Area.
The Thick Lines show the Cable Routes as at present located.

It is probable that the current will be distributed to a good many foundries.

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Pridmore Moulding Machines.—In evidence of the extended use of this machine in the United States, Mr. H. E. Pridmore informs us that in the works of two companies only, namely, the International Harvester Company, and the General Electric Company, there are no fewer than 1,200 Pridmore moulding machines in use. This is a record which has certainly never been approached by any other moulding machine, and is a clear proof that the Pridmore machine is built on the right principle, and has no equal either in simplicity, durability, or efficiency. Messrs. Jackman & Company are the agents in this country.

THE POSITION OF THE STEEL FOUNDING INDUSTRY IN AMERICA.

THE steel-casting industry in the United States has had not a little attention in recent years. Manufacturers of grey iron and malleable castings have been hearing from time to time of the substitution of steel for their products, and there has been also some use of steel castings instead of forgings. However, an examination of the statistics of the industry would indicate that perhaps undue importance has been attached to the effect of the displacement of grey iron and malleable castings by steel castings. It is true that cast-steel frames for locomotives are taking the place of forged frames, and that this means five tons of steel castings for the average locomotive. It is true, also, that draw bars are now largely specified to be steel castings instead of malleable castings, and that car bolsters and centre plates and wheel centres come from the steel foundry. It is well known, moreover, that steel rolls and housings and other steel castings are increasingly in use in rolling mills. In the discussions on the inroad of steel upon grey iron these facts have been given prominence, and the deduction has been made that grey iron and malleable castings have a steadily narrowing field.

The statistics of the American Iron and Steel Association show that the production of the various cuasses of steel castings has been as follows, in the four years named:—

Production of Steel Castings in the United States—Gross tons.

	1900.	1902.	1903.	1904.
Acid open-hearth	134,847	255,475	255,469	203,915
Basic open-hearth	42,644	112,404	134,879	98,919
Bessemer ...	6,467	12,548	18,099	16,054
Crucible ...	3,989	4,955	5,409	4,305
Miscellaneous	4,856	5,553	6,409	7,018
Total ...	192,803	390,935	420,265	330,211

It will be seen that the falling off in 1904 from the high record reached in 1903 was marked, being no less than 23 per cent., and that the output of steel castings last year was 60,000 tons less than in 1901. There are no statistics of the production of grey iron, chilled iron, and malleable castings, but some comparison can be made between the last two years by taking the production of foundry and malleable Bessemer iron. For 1903 the production of foundry iron in the United States was 4,409,023 gross tons, and of malleable Bessemer 473,781 tons. Last year the production of the two classes of iron amounted to 3,827,229 tons and 263,529 tons respectively. This indicates a decline of 16.2 per cent., but stocks of iron were less on December 31 than on January 1, 1904, so that the actual falling off in the consumption of grey iron and malleable castings last year, as compared with 1903, was probably less than 15 per cent.

But perhaps the most striking impression that will be obtained from the figures is that of the relatively small proportion of the total of castings produced in the United States that comes from steel foundries. It is probable that not more than 6 per cent. of the total of iron and steel cast in sand moulds in 1904 was steel.

THE FOUNDRY AND STRUCTURAL ENGINEERING.

IN a paper read by Mr. W. Doig Gibb before the Institution of Gas Engineers some interesting observations are made on the current practices in structural engineering. Particularly the author points out examples of expensive design, a good instance of which is often found in a combination of flanged cast-iron plates. It is, of course, desirable that as large plates as are conveniently possible should be used, so that flanges, machining, jointing materials, and bolts may be saved; but there is a practical limit to their size and to the size of the plant which an ordinary manufacturer has at his command. Plates which are beyond an ordinary size entail greater cost per ton in moulding. They have, in addition, a greater tendency to warp in cooling, and so to be rendered useless; and there is a greater chance of breakage in handling while being dressed, machined, sent forward, and erected. In consequence, very large plates, area for area, are generally more expensive than smaller ones, when everything is reckoned up, and the contractor's risks are covered.

In elaborate and special castings a knowledge of foundry work is also very desirable, so that the design may be one which it is possible to produce in metal at as cheap a rate as possible. Elaborate single castings are sometimes much more expensive than if their forms were built up in different sections, inasmuch as they sometimes require very intricate and expensive work in moulding; and if the thicknesses of metal in them vary much

there is a great danger that a large proportion of them, when cast, will turn out to be "wasters." In addition, even if an elaborate single casting be turned out to look all right, there cannot be much reliance placed upon the strength of its sections throughout, as, with elaborate cores, etc., it is extremely difficult to get the whole of the metal solid and of proper dimensions. It may be argued that the thicknesses can be afterwards calipered, but even if this be possible—and it is not always possible—the discovery of wrong thicknesses or of unsound metal will result in the condemnation of the casting; and so the argument still holds good—that the design may be an expensive one.

In many cases it is possible to caliper the thicknesses of cast iron, and it is specially desirable to do so in the case of cast-iron cylinders, whether they may be pipes or columns. Unless the cores of cast iron cylinders be very carefully constructed, dried, and fixed there is a tendency—especially if the cylinders be of considerable length—for the cores to shift their positions when the molten metal comes upon them, and this often results in the cylinders having a thick and a thin side. This is bad enough in the case of a pipe, but is worse in the case of a column, which may have been calculated to take a certain dead weight upon it, and where, in consequence of a thick and a thin side, the conditions are entirely changed. The writer has noticed many columns which are not designed in a proper manner, inasmuch as they have ornamental overhanging heads, and projecting bases which are not strengthened up by interior ribs. These may be the cause of very serious disaster, since, if there has only been a simple calculation taken of the weight which the shaft of such a column will support, and if the head or base has got such a projection as will cause a portion of the metal to be subjected to a shearing action instead of a solid down-thrust, the column has nothing like its calculated strength in giving support.

The desirability of designing cast-iron work with as nearly as possible equal thicknesses of metal seems to be often lost sight of, though extreme variations undoubtedly cause the cold castings to have varying internal strains upon their several members which tend to upset the accuracy of the calculated safe strains or loads which the castings will bear.

It is essential that in all designing work great thought should be given as to how the design can be manufactured. The employment of steel and wrought iron is becoming much more common than formerly.

In conclusion, the author states that slow progress in structural engineering is, in many places, shown by :—

1. The unnecessary employment of expensive and unreliable forgings and smith work.
2. The disregard of how the work is to be constructed and fitted in contractor's yard and erected on site.
3. The adoption of elaborate built-up girders, trusses, etc., where simpler and less expensive designs would serve the same purpose.
4. The use of built-up members in place of rolled sections.
5. The continued employment of built-up thin plates instead of using the thicker plates now on the market.
6. The continued employment of cast-iron instead of rolled sections.

For the sake of economy, careful design must include a due consideration of—

1. Proportion of material.
2. The use of the cheapest and most easily obtained suitable material.
3. Reduction to a minimum of labour in manufacture.
4. Reduction to a minimum of labour and plant required in erection.

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ONE CAUSE OF UNSOUNDNESS IN GUN METAL CASTING.

By G. E. Buttenshaw, A.M.I.Mech.E.

It will doubtless be readily admitted by all engaged in the various departments of engineering science that remarkable strides have been made within so short a period as the last fifteen years, and this rapid forward movement of inventive skill and genius on the part of the civil and mechanical engineer has called for a corresponding response on the part of the metallurgical engineer to provide the increased efficiency of material demanded and a more thorough knowledge of the ethics of his profession.

It may truly be said that the metallurgist has, during this time, risen to the occasion demanded of him, as witnessed by the now more intimate knowledge of the iron-carbon alloys, and the fruitful researches made by able workers by means of microscopic analysis and thermal measurements.

But while so much attention is being given to the physical properties of steel, and laboratory experiments and researches are being more and more applied to guide and direct the practical work in the workshops, it would appear that little attention has been given to

investigating many of the problems that arise in the foundry practice of the bronzes.

It is true that splendid work has already been done in the examination of the properties of copper-tin and copper-zinc alloys, which prepares the way for the application of the knowledge thus obtained to the practice in the foundry,

FIG. 1.

but of this actual application one finds little on record as yet.

It is the object of this short paper to call attention to a few of the many interesting points which have come within the author's experience.

Probably the fact that little is heard of any difficulties with these alloys is due to the fact that their more general use is for small and light work, and given proper care in the selection of materials, melting of metals, moulding, etc., little trouble is experienced beyond the occasional "waster" found under hydraulic test.

But with the increasing demand, for large works and increased strengths, made by naval requirements, a different and more complex situation is opened up; and in this class of work, when rejection takes place, a very large expense and loss is incurred, hence it is very necessary to obtain all the assistance that science can give to avoid what becomes, during a year's working, a very serious item in a large foundry.

It is reasonable to assume that alloys of metals, when liquid, consist of a solution or solutions of one or more metals in another metal, and that when solid, certain solutions (not necessarily chemical compounds) crystallise out, and that the composition of these solidifying solutions varies with the initial composition of the alloy, and, secondly, with the initial temperature of casting and the rate of cooling.

Referring to Figs. 1 and 2, which are photo-micrographs of gun metal (so-called) under a magnification of 52 diameters. Fig. 1 is taken from a small casting weighing 2½ lbs., while Fig. 2 is from a casting weighing 94 lbs., both solid castings.

At the time of casting, the temperatures were measured by means of a thermo-couple placed in the mould at the place furthest from the runner.

In the case of Fig. 1, the temperature in the mould at the moment of casting rose to 900 degrees C., and the casting cooled down 600 degrees C. in 40 minutes.

Fig. 2, however, rose to 1,100 degrees C., and cooled 600 degrees C. in 100 minutes; the temperature of the metal in the crucible being about 1,110 degrees C. at the time of casting in both cases.

The photo-micrographs readily show that there is a physical difference between these two castings, which may also be expected to have some influence on the ultimate strength, ductility, etc., and also upon other properties which will be referred to later.

This alloy (which contains 13 per cent. of tin) would commence to solidify at about 970 degrees C., when the alpha

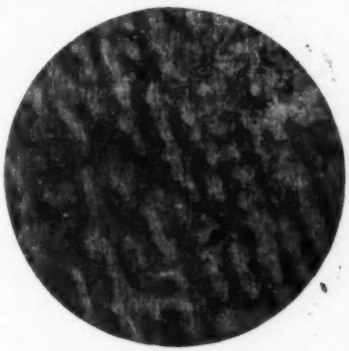

FIG. 2.

crystals would begin to form, which formation contains up to 7½ per cent. of tin. This formation stops at 780 C., and this point is reached in the case of Fig. 1 in 4 minutes after casting, and in the case of Fig. 2 in 30 minutes after casting. From this it will be understood that the rate of cooling produces an effect upon the relative amount or size of primary structure formed in the mass which is apparent in the figures; the

alpha crystals are seen light in the photographs.

The most important effect, which it is the purpose of this article to draw attention to, is that which the rate of cooling has upon the matrix or mother liquor in which the alpha crystals have formed.

Very complex transformations occur below the 780 degrees C. point, according

FIG. 3.

to the rate of further cooling, the nature of which need not be traced out in detail within the scope of this article, but it is sufficient to say, that under certain conditions, solid solutions may, as the temperature falls, further resolve themselves even so far as to become again liquid, with the formation of other solid solutions until the final solidification of the eutectic is reached.

To this physical effect certain troubles can be traced, as will be seen by Fig. 3, which is Fig. 2 magnified 240 diameters, and is the appearance presented of a porous or spongy condition of the metal and helps to indicate to what cause the spongy condition is due. From the preceding it will be readily understood that at a certain temperature the casting consists of a network of primary substance surrounded by a still liquid mass, in which, if slowly cooled, cavities will be formed by the combined action of contraction and gravitation on the slowly cooling surround. Such cavities are shown in Fig. 3, and another specimen is shown in Fig. 4, which has been heat-oxidisation tinted instead of acid etching, in order to show the composition rather than the crystallisation of the alloy. In Fig. 4 it is seen that the tin-rich matrix has drained away from between the already solid copper-rich crystals and left a cavity. When a chain of such cavities extend through the walls of a casting, the latter will not be sound under hydraulic pressure, and it may most likely happen that these cavities are only exposed after boring, turning, or drilling the casting, as the skin is chilled to some extent by contact with the mould, hence the casting becomes waste after expense in the form of machining has been added to the cost of making it.

This is more likely to occur in castings which are of some depth, and which have been designed to resist high pressures. The author has seen cases where increased thickness was added to allow for an increase of pressure, and this trouble began to be manifest. It is more than probable that such inherent defects are present in castings which have gone into use, having fortunately, or unfortunately, not shown themselves, or have been "faked" before inspection. Very much can be done to counteract this by a proper understanding of the correct method of gating and casting demanded by the physical conditions imposed, and it must not be overlooked that a casting is not necessarily finished when the mould is filled; thermo-physical actions take place which will have a result on the work, and a moulder may be quite at a loss to know to what to attribute the trouble. It may be suggested that what is wanted is proper feeding, but

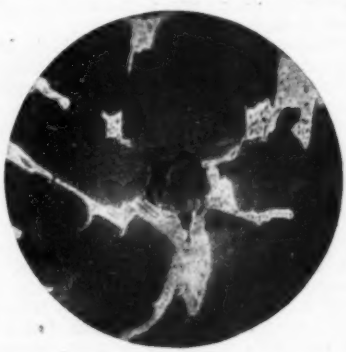

FIG. 4.

this is not the correct solution of the difficulty, as the action described takes place after ordinary feeding would be suspended. It may be somewhat open to question whether the so-called gun metals are suitable for all the purposes for which they are still so strictly specified.

Other bronzes are coming more into use for this class of work, primarily on account of their greater strengths, but in regard to these, it is advisable to obtain

an insight into the effect of thermal conditions on the formation of the solid solutions, so that efficient scientific guidance may be applied so as to obtain the best possible results. It may be taken for granted that thermo-physical conditions will affect mechanical properties very largely in copper-zinc bronzes, and an alloy, which may give excellent results under the conditions surrounding a small test piece, may, in the bulk of a large casting, make a very poor show, and the efficiency expected by the engineer is far from being obtained.

This short article does not attempt to enter into the many other conditions which go to produce bad effects in bronze castings, but only to point out the importance of considering thermal conditions, and the suitability of certain alloys for certain classes of work. In conclusion, it might be interesting to quote the words of an eminent worker in the field of alloy research who says: "He had never seen a piece of ordinary gun metal casting that appeared to be sound under the microscope."

——o——

QUERIES.

This department of the JOURNAL *undertakes the answering of queries in foundry practice and pattern-making. We trust our readers will afford us assistance in answering these queries so far as possible.*

MOTOR CAR CYLINDERS.—In reply to the T. P. Company, Limited, who asked in our last issue for information regarding the casting of sound cylinders for motors, "Drybrush" writes:—"I hope the following mixture of sand will be of some use to 'T. P. Company,' Limited, for his cores and the ending of his troubles. It is this same mixture that I have used for our cylinders for months past with great success. Let 'T. P.' look in his roof spouting near the furnace and he will find a gritty dust. Take two double-handsful of this dust, two and a half shovels of red sand, two shovels of black sand, half a teacup of core gum. Mix these ingredients (before wetting) thoroughly by passing through a one-eighth sieve once or twice. Do not add any coal dust whatever. When the core is made bake quickly, but do not put it too near the fire or it will blister. But whatever sand 'T. P.' uses he *must be sure* that his vent holes are properly open all through the core, and he must bring his gas off in such a way that the metal does not find its way in. Seeing that the vents are clear and keeping the metal out is half the battle. 'T. P.' says he cannot use rods in his cores. Is he quite sure of this, because I use rods in mine. I use $\frac{1}{8}$-steel wire, and bend it as little out of straight as the core box will allow. Then when the casting is cooling, and about a cherry red, I get a little of the core out (generally as far as the first bend), and holding the wire by a pair of close tongs I put one foot on the casting and give a straight, steady pull. Do not twist the wire or it will break. The wire being at red heat with the casting, by pulling straight, the wire bends itself as it comes to the bends. I hope "T. P. Company" will find this help him out of his troubles, but if it should not I would advise him to get a man that has been used to this sort of work. Of course, this will cost money, but he will find it cheapest in the long run. Let 'T. P.' try one of his cores with this mixture and one with wires as I have described, and I think he will have some good sound castings."

BLOWN HOLES IN CASTINGS.—In reply to "Troubled" (August Number), "Patriot" writes:—"I regret that I cannot offer any mixture for filling up blown holes in motor cylinder castings, nor would I advise using any. As one who is acquainted with the difficulties of the same, I fail to see how it could be made to fasten itself in a blown hole, as they are generally very smooth and not very good for holding anything; not the same as a rough sand hole. But another question is, are we keeping up the name of English workmanship? The writer thinks that if 'Troubled' would reduce the sulphur in the metal and coke his trouble would be over."

COST OF MOULDING MOTOR CYLINDERS, "P. B. T." writes:—Can any of your readers give the cost of moulding a double motor cylinder?

PLOUGH SHARES, "A. E." writes:—"I should esteem it a favour if you could give me a little information on the making and chilling of plough shares, and not only the chilling, but the best metal used for making the best plough shares, that is, so that they will wear sharp the same as Howard's, Cooke's, and Ransome's?"

——o——

MR. R. HOLDER, a member of the Jessop Steel Company, and Mr. S. Tucker, of Sheffield, are in the United States studying methods of making steel.

TRADE TALK.

THE LONDON AND GLASGOW ENGINEERING COMPANY have expended £7,000 on new machinery and in extensions.

MESSRS. CAMPS & COMPANY, consulting engineers, etc., of 102, Fenchurch Street, E.C., have removed to 6, Crosby Square, E.C.

THE first steel manufactured at the Cargo Fleet Iron and Steel Works, Middlesbrough, has been produced during the month.

IT is officially announced that there is no truth in the statement that the Blyth Shipbuilding Yard and Docks have changed hands.

MESSRS. THOMAS PIGGOTT & COMPANY, of Birmingham, have secured an order for 17 of their patent stamped steel tanks for South America.

THE NEW TRADES PROGRESS COMPANY has been formed to carry on the business of ironfounders, etc. The capital of the concern is £16,000.

THE INDUSTRIAL ENGINEERING COMPANY, of Newton Iron Works, Hyde, have removed their head offices to 12, Exchange Street, Manchester.

MESSRS. ROBERT MCFIE & SONS, engineers, Glasgow, have sold their business to Mr. R. M. Mitchell, of 24, Howard Street, Bridgeton, Glasgow.

MESSRS. HAWTHORN, LESLIE & COMPANY, LIMITED, are building additional shops and buying new machinery in view of the introduction of turbines.

VERITY'S, LIMITED, of Aston, Birmingham, are establishing a new department at each of their branches for the sale of Aston ventilating fans and blowers.

CAMMELL LAIRD & COMPANY, LIMITED, of the Cyclops Works, Sheffield, have received from the Admiralty an order for about 2,000 tons of armour-plates.

MESSRS. SAMUEL OSBORN & COMPANY, of Sheffield, have been re-modelling the driving appliances at their steel works by the introduction of gas engines.

THE CARGO FLEET COMPANY recently received delivery of two 16-in. cylinder locomotives from Andrew Barclay, Sons & Company, Limited, of Kilmarnock.

THE STEEL COMPANY OF SCOTLAND, LIMITED, expended £33,000 last year on additions to, and reconstruction of, plant, principally at Blochairn and Hallside.

MESSRS. J. & R. THOMAS, of Walsall, are preparing to blow in a new furnace owing to the increased demand for pig-iron in the South Staffordshire district.

T. W. GREENWELL & COMPANY, LIMITED, ship-repairers, of Sunderland, have now removed to new premises on the River Wear Commissioners' No. 1 Graving Dock Side.

THE STEEL COMPANY of Scotland has secured large contracts from two foreign Governments for steel plates. The delivery extends over a period of two years.

THE DARLINGTON ROLLING STOCK COMPANY have recently acquired the repairing shops of the Darlington Railway Wagon and Engineering Company, Limited.

A DISSOLUTION of partnership is notified in connection with Messrs. E. Haigh and J. Rigg, trading as Haigh & Rigg, Littleborough, Lancashire, mechanical engineers.

MESSRS. SHOOLBRED & CONNAL, engineers, 146, Fleet Street, E.C., have been appointed sole British agents for the sale of "Red Cross" lubricant for commutators.

THE plant and stock of the Milton Foundry, Hoyland, have been purchased by Messrs. Aizelwood & Taylor, iron and steel merchants, for purposes of dismantlement.

THE directors of Palmer's Shipbuilding and Iron Company, Limited, are contemplating further large expenditure on the company's steel works, in order to bring them up to date.

CHARCOAL burning has been started in the woods at the south end of Windermere, and a supply of charcoal is being stored for the old Backbarrow iron smelting furnace.

SMITHERS & JEYNES, LIMITED, is the name of a new company registered to acquire the business of engineers carried on by Charles Wood, Limited, at Cargo Fleet, Middlesbrough.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, have appointed Mr. C. E. Jones their London agent for pipes and castings. The company's offices are at 34, Victoria Street, S.W.

MESSRS. F. TWEEDY, A. F. YARROW, and M. ROBINSON, engineers, Newcastle-upon-Tyne, trading as the Turbine Investigation and Advisory Syndicate, have dissolved partnership.

SMITH'S DOCK COMPANY, LIMITED, have decided to carry out extensive improvements at their North Shields Docks. Two existing dry docks are to be enlarged, and new and modern engineering shops are to be erected.

GUEST, KEEN & NETTLEFOLDS, LIMITED, are now engaged in re-equipping the last of the blast furnaces at their Cardiff Works. When this is finished, the whole of these furnaces will be ready to be put into operation.

AN all-steel railway carriage was exhibited recently at the Metropolitan District Railway car depôt at Mill Hill Park. The car was built by the Brush Electric Engineering Company, and weighs only 15 tons 17 cwt.

MESSRS. BALCKE & COMPANY, of 27, Clement's Lane, London, have opened new offices in Newcastle and Glasgow, and have appointed Mr. J. E. Weyman their sole representative for Scotland and the North of England.

HORN, LITTLEWOOD & COMPANY, LIMITED, has been registered with a capital of £1,000, in £1 shares, to acquire the mechanical engineering business carried on at Gainsborough, Lincolnshire, as Horn & Company.

SAMUELSON & COMPANY, LIMITED, has been registered with a capital of £100,000, in £5 shares, to acquire the business of ironfounders, etc., carried on by Samuelson & Company, Limited, Britannia Works, Banbury, Oxon.

THE GRANTHAM CRANK AND IRON COMPANY, LIMITED, have altered the name of the firm to the Grantham Boiler and Crank Company, Limited. The company are now putting down some new and more powerful tools at their works.

MESSRS. DUNSMUIR & JACKSON'S new engineering works at Govan are approaching completion. The new shops have a frontage to Windsor Street, Govan, of 300 ft., and to Baird Street of 85 ft., and the central section has a height of 60 ft.

THE DARLINGTON FORGE COMPANY recently completed castings for the stern frames and rudder posts for two Cunarders which are to be erected, the one by Messrs. J. Brown & Company, and the other by Messrs. Swan, Hunter & Wigham-Richardson.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING COMPANY, LIMITED, are carrying out considerable improvements at their works, chiefly the installation of electrical power. Two 25-ton electric cranes have been erected at the company's works lately.

AT the London Bankruptcy Court, this month, the public examination has been held of A. G. New, engineer, of St. Martin's Lane. The statement of affairs showed liabilities £19,740, of which £13,140 were unsecured, and assets £38. The examination was concluded.

UNDER the style of Adrian, Chambers & Company, Limited, a company has been formed with a capital of £10,000, in £10 shares, to acquire the business carried on at Killamarsh, Derby, as Adrian, Chambers & Company, and to carry on the business of steel founders, etc.

THE WESTINGHOUSE BRAKE COMPANY, LIMITED, have secured the exclusive rights to manufacture the Morse Rocker Joint Silent High Speed Chains in Great Britain and on the Continent, and have just completed a new building at York Road, King's Cross, N., for the manufacture of these chains.

PROFESSOR ARNOLD, of Sheffield University, delivered a lecture recently before the British Association in South Africa on "Steel as an Igneous Rock." He said that researches carried out at Sheffield University proved that steel with a high elastic limit was as a rule more liable to rupture than softer, low-limit steel.

THE Admiralty have given out the orders for the heavy armour plates for the battleships now building. These are divided between Messrs. William Beardmore & Company, Limited, Messrs. John Brown & Company, Limited, Messrs. Vickers, Sons & Maxim, Limited, Messrs. Cammell Laird & Company and the Armstrong-Whitworth Company.

COMPANY NEWS.

PYLE AND BLAINA WORKS, LIMITED.—Final dividend of 2½ per cent.

ALLEY & MACLELLAN, LIMITED.—The usual interim dividend on the preference shares.

WILLIAM JESSOP & SONS, LIMITED.—Interim dividend of 5 per cent. per annum.

MUNTZ'S METAL COMPANY, LIMITED.—No interim dividend has been declared on the ordinary shares.

THE LINCOLN WAGON AND ENGINE COMPANY, LIMITED.—Interim dividend of 5 per cent. per annum.

KAYSER, ELLISON & COMPANY, LIMITED.—Further dividend of 7s. 6d. per share (making 12½ per cent. for the year).

PALMER'S SHIPBUILDING AND IRON COMPANY, LIMITED.—Final dividend of 5 per cent. per annum on the ordinary shares.

ALEX. TURNBULL & COMPANY, LIMITED.—No dividend has been declared on the 5 per cent. cumulative preference shares for the half-year.

STAVELEY COAL AND IRON COMPANY, LIMITED.—Final dividend of £4 10s. per share on the A and C shares, and of 15s. per share on the B and D shares.

STEWARTS & LLOYDS, LIMITED.—Half-yearly dividends, 6 per cent. per annum on the preference shares, and 9 per cent. per annum on the ordinary shares.

LONDON AND GLASGOW ENGINEERING COMPANY, LIMITED.—Balance at the credit of profit and loss account, £17,277; dividend, 7½ per cent.; carried forward, £1,438.

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED.—Yearly dividend of 15 per cent. on the ordinary shares, and 4 per cent. on the preference shares, carrying forward £84,033.

STEEL COMPANY OF SCOTLAND, LIMITED.—Gross profits for year £92,754, and £2,443 was brought forward. Reserve fund, £5,000; ordinary dividend 5 per cent.; carried forward, £4,265.

HARDY PATENT PICK COMPANY, LIMITED.—Net yearly profit, £8,372 9s. 6d.; preference dividend, 7 per cent.; ordinary dividend, 10s. per share; reserve fund, £2,000; carried forward, £1,668 9s. 6d.

SUMMERLEE AND MOSSEND IRON AND STEEL COMPANY, LIMITED.—Dividend, £1 per share; special reserve fund, £50,000; ordinary reserve fund, £30,000; reserve for surface restoration, £7,200; balance forward, £5,554.

LANARKSHIRE STEEL COMPANY, LIMITED.—Interim dividend of 5s. per share, less income-tax, on the 5 per cent. cumulative preference shares, and 15s. per share, less income-tax, on the 5 per cent. cumulative preference shares (1899), being dividends for the year 1903 and the first half of 1904.

THE PEARSON AND KNOWLES COAL AND IRON COMPANY, LIMITED.—Half-year's dividend of 6 per cent. per annum on the preference shares, also a half-year's dividend of 5 per cent. per annum on the ordinary shares. Reserve fund increased by £10,000, and £8,082 carried to next account.

ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

Contractors to H.M. Government.

FOUNDRY LADLES

JAMES EVANS & Co., FOUNDRY ENGINEERS,

Telegrams!
"LADLES, MANCHESTER."

BRITANNIA WORKS, MANCHESTER.

PERSONAL.

MR. HENRY DUNCAN MCLAREN has been elected a director of Palmer's Shipbuilding and Iron Company, Limited.

THE late Mr. William Jessop, chairman of William Jessop & Sons, Limited, Sheffield, left estate valued at £90,382.

THE late Mr. J. Spencer, of John Spencer & Sons, Limited, left property valued at £358,103 net and £370,074 gross.

SIR LINDSAY WOOD, BART., has presented a handsome silver challenge cup to Chester-le-Street and District Cricket League.

THE late Mr. J. L. Houston, of Messrs. Punchard, Lowther & Company, engineers, London, left estate valued at £23,858.

THE gross value of the estate of the late Mr. D. Davies, of the Redheugh Iron Works, Gateshead, and the Dunston Iron Works, is £40,158.

THE gross value of the estate left by the late Mr. G. A. Everitt, of Messrs. Allen Everitt & Sons, brass founders, Birmingham, is £96,046.

MR. J. A. SLATER, of Messrs. James Slater & Company, engineers, High Holborn, W.C., who died on May 15, left estate valued at £49,453 7s. 7d. gross, and at £44,263 15s. 5d. net.

PROPERTY of the value of £233,349 2s. 6d. has been left by the late Mr. W. Bruce Dick, founder of the electrical engineering firm of Dick, Kerr & Company, Limited, Cannon Street, E.C.

MR. H. MOSS, lately connected with the Meteor Electrical Engineering Company, has been appointed manager of the electrical department of Messrs. David Wilson & Company, of Huddersfield.

MR. A. L. MELLANBY, lecturer in engineering at the Manchester School of Technology, has been appointed to the Chair of Engineering in the Glasgow and West of Scotland Technical College.

M. HEROULT, of La Praz, France, inventor of the Héroult electric smelting furnace, is in Canada supervising the experiments in electric smelting which are to be made in Sault Ste. Marie, Ontario.

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OBITUARY.

MR. JOHN YOUNG, of J. & W. Young, Stobcross, Glasgow, brassfounders.

MR. WILLIAM WOOD, engineer to the National Gas Engine Company, Limited, of Ashton-under-Lyne.

MR. R. BARKER, for many years head of the firm of J. Barker & Sons, Phœnix Foundry, Millwood, Todmorden.

MR. JAMES MAXWELL, proprietor of the Clydesdale Iron Foundry Company, of 210A, Upper Thames Street, E.C.

MR. SAMUEL JESSE PARSONS, a member of the firm of Messrs. David Parsons & Sons, Cradley Heath, and a partner and manager of Parsons, Limited, engineers and ironfounders, Brierley Hill, in his 48th year.

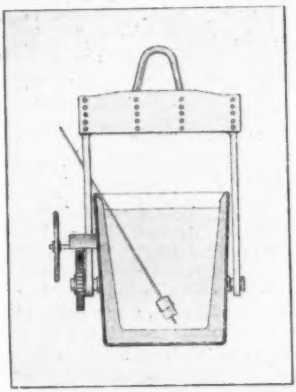
MR. CHARLES PERKINS, J.P., of the Birtley Iron Works, Birtley, Northumberland, and a director of the Consett Iron Company, Limited. The erection of some permanent memorial to the late Mr. Perkins is at present under consideration at Birtley.

MR. R. M. DAELEN, who was born in Prussia in 1843, and commenced his long and intimate connection with the iron and steel trades at the foundry and rolling works of Messrs. Piepenstock, of Hörde. The deceased was the author of numerous papers on foundry practice, and also studied very closely various questions relating to steel castings.

Ganister, Cupola Blocks, Fire Bricks,
Fire Clay.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
Steel Moulders' Composition, Silica Cement.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

PREVENTION OF BLOWHOLES IN CAST IRON.



A tin of our special compound fixed on a rod is held at bottom of ladle as shown; a strong re-action being thereby set up frees the iron from gases and impurities, which rise to the top.

RESULT: A denser casting of finer grain with increased strength.

For Particulars apply to—

THERMIT LIMITED,

27, MARTIN'S LANE, CANNON STREET,

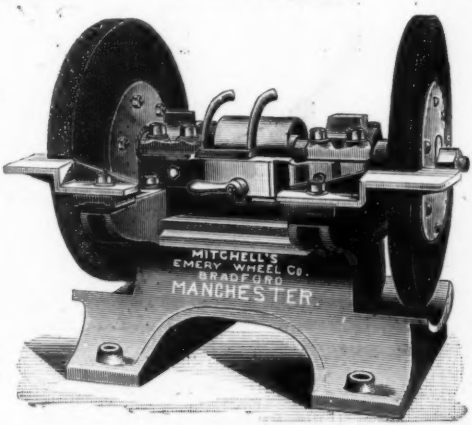
Telephone—3749 Central.
Telegrams—"Fulmen," London.

LONDON, E.C.

MACHINES. For all Purposes. **WHEELS.**

Complete with Emery or Corundum Wheels from **£2** upwards.

Special Machines Designed.



Emery or Corundum from 1 in. x $\frac{1}{8}$ in. to 50 in. x 12 in.

Enquiries solicited.

MITCHELL'S EMERY WHEEL Co.,

Mill Street, Bradford, MANCHESTER.

Also at LONDON, GLASGOW, and BELFAST. LISTS FREE.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	1904-5.	1903-4.
Iron—Scotch pig warrant ... ton	—	—
—Middlesbro' warrants ... ... ton	52/0½	43/6
—W.C. M/nos Bessemer ... ... ton	66/0	53/6
—Stock, Scotch, Oct. 5 ... ...tons	16,640	9,551
Copper—Chili bars, GMB ... ... ton	£71 5/0	£58 18/9
—Stock, Europe & afloat... ... tons	16,304	13,878
Tin—English ingots ton	£150 5/0	£124 10/0
—Straits ... ton	£148 7/6	£129 7/6
—Stock, Ldn. Hind and aflt ... tons	13,386	14,502
Lead—English pig ton	£14 16/3	£12 5/0
Spelter—Ord. Silesian ... ... ton	£27 15/0	£22 10/0
Quicksilver-(75lb.) bottle	£7 5/0	£7 15/0
Antimony—Regulus ... ... ton	£56 0/0	£25 15/0

Castings.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 12 6	to	7 2 6
Pipes, 1½ to 2½ in.	5 0 0	to	5 2 6
,, 3 to 4 in....	4 12 6	to	5 0 0
,, 5 to 8 in.	4 10 0	to	4 12 6
,, 10 to 16 in....	4 10 0	to	4 12 6
,, 18 to 24 in....	4 10 0	to	4 12 6
Chairs	3 12 6	to	3 15 0
Floor plates (open sand)	3 2 6	to	3 5 0

Scrap.

The quotation for scrap subject to market fluctuations is as follows :—Engineers' heavy scrap, 52s. 6d. to 55s. ; ditto light scrap, 20s. to 22s. 6d. ; clean scrap brass, 41s. ; clean scrap copper, 65s. ; lead (usual draft), 12s. 9d. ; tea lead, 11s. 6d. ; zinc, 21s. ; hollow pewter, 100s. ; black pewter, 65s. per cwt.

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Nalder Brothers & Thompson, Limited, intimate that Mr. E. Roberts, of 6, Holborn Place, has resigned his position as their London representative, and has been succeeded by Messrs. Frampton, Paine & Jackson, of 29, Old Queen Street, Westminster.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

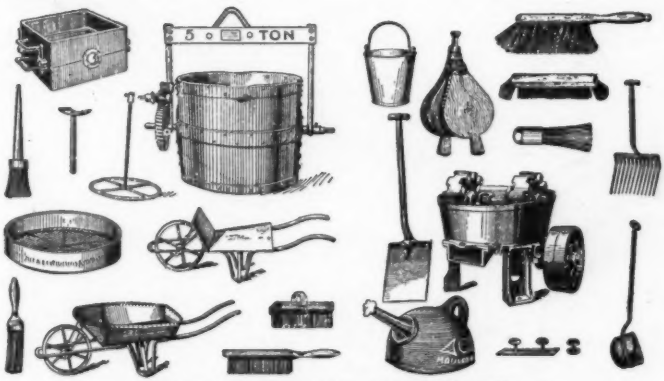
GROUND GANISTER,

Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Established 1863.

Jas. Durrans & Sons,



PHŒNIX WORKS, PENISTONE,

Nr. Sheffield.

Manufacturers of all

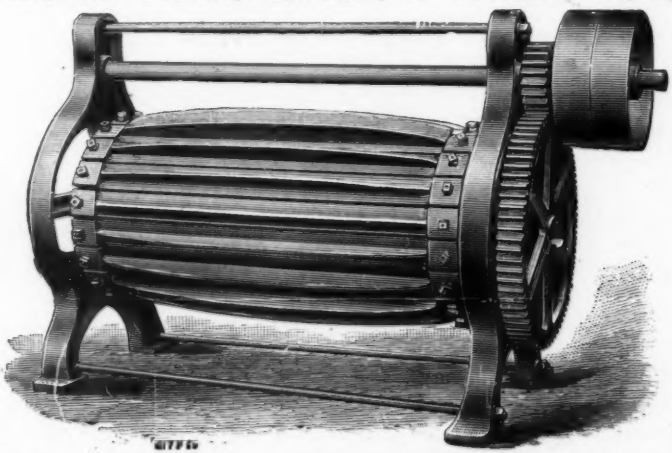
FOUNDRY EQUIPMENTS

Composition Black Lead,

Plumbago, Core Gum, White Dust, and Coal Dust.

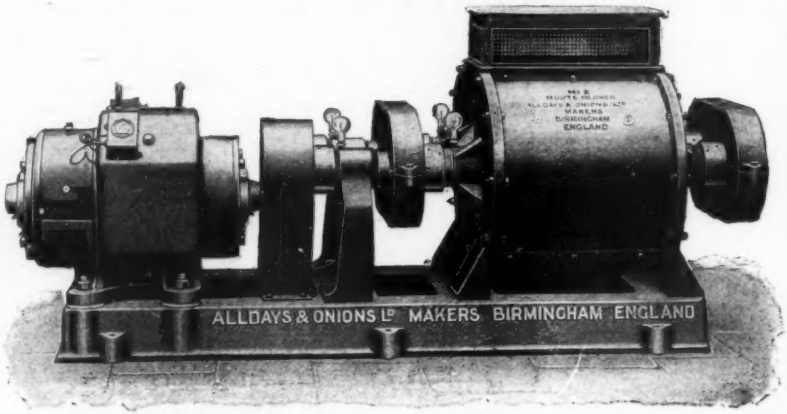
Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

ROOTS BLOWERS.



ALLDAYS & ONIONS PNEUMATIC ENGINEERING CO., LTD., BIRMINGHAM.

AND AT 20 BUCKLERSBURY, LONDON, E.C. Telegrams: "ALLDAYS, FIRMINGHAM."

38¼"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW.
36"
32½"

Can also be made in Aluminium.

FOR SALE.

Scott's Wheel Moulding Machine, equal to new.
New 3 ft. 6 in. Loam and Sand Mill.
New Moulding Sand Mixer. Capacity, 5 to 10 tons per hour.
Thwaite's Root's Blower, 11½ in. discharge.
Thwaite's Root's Blower, combined with Vertical engine. Melting capacity, 3 tons per hour.
No. 4 Root's Blower, by Alldays, to blow 50 fires.
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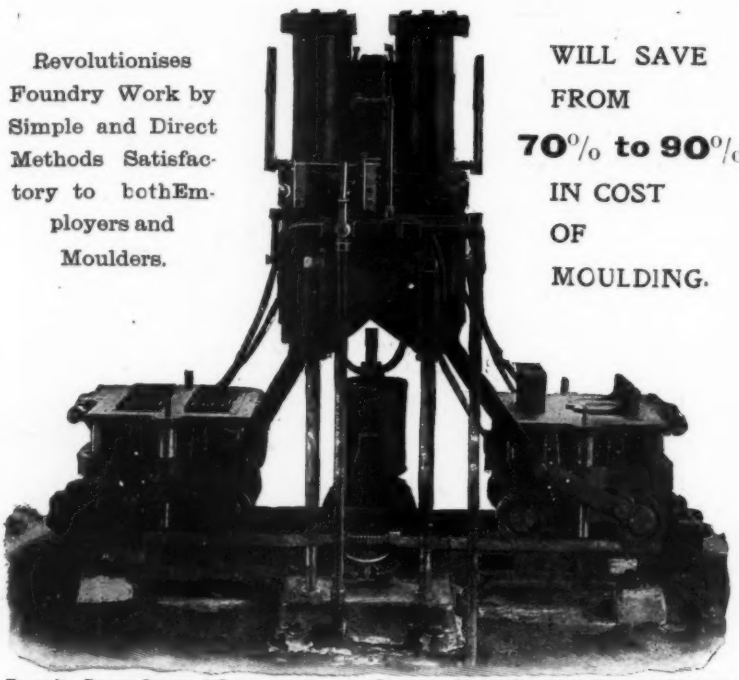

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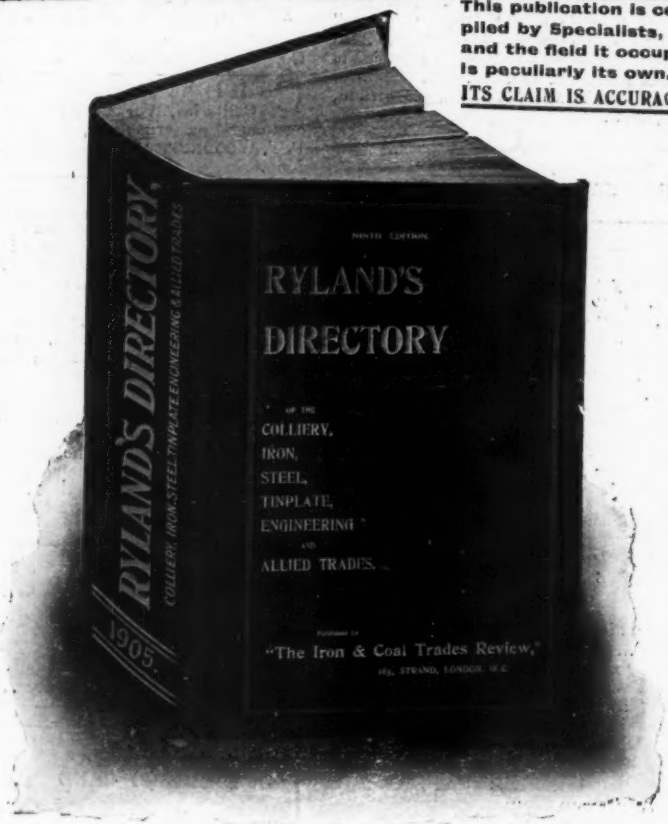

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